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Recent Improvements in Black-and-White Film Recording for Color Television Use

By WILLIAM L. HUGHES

At the 1955 SMPTE Convention at Chicago, a method of recording television images on black-and-white film was described. At that time, certain difficulties regarding light efficiency, noise and image definition were yet to be resolved. In the last year, refinements have been made in the electronic and optical characteristics of the system to the extent that the overall picture quality now compares very favorably with that obtainable on 16mm color film. This paper is concerned with a discussion of how these refinements were achieved.

In the last two years, three papers have been presented which describe a method of recording color television images on black-and-white film.*

The system is, in theory, capable of all of the recording functions currently required by the color television broadcast industry. First, films can be taken by a mechanical camera and played directly after development on the flying-spot scanner reproducer. Secondly, the system is adaptable to a relatively easy method of making kinescope recordings. In addition, there are certain obvious advantages with regard to ease and cost of operation as well as picture quality theoretically obtainable when compared with present-day 16mm color film. These advantages are discussed in detail in the previous papers and will not be elaborated here.

The basic reproducer system is illustrated in Fig. 1. Vertically compressed television fields are shown on a continuously moving piece of film. The left-hand column of images represents successive fields of the luminance signal. The righthand column of images represents alternate fields of chrominance information which in this illustration are red and blue. As the film moves continuously, an image from the scanner tube is focused by means of a beam splitter on each of three film images; they are a luminance image, the chrominance image beside that luminance image, and the chrominance image directly above and to the right of the luminance image. The cathode-ray scanner tube produces either a single line scan or a very narrow raster. This narrow raster might be produced either optically or electronically. Photomultipliers gather the light from each of the three scanned images. Photomultiplier 1 continuously reads luminance information at the same time that photomultipliers 2 and 3 are continuously reading chrominance information. If the recorded chrominance information is red and blue, then photomultiplier 2 will read red one field, blue the next field, red the third field, and so on. Photomultiplier 3 reads different color information on successive fields as does photomultiplier 2; but in any given field, one of them reads blue and the other reads red.

An electronic switch keyed at a field rate is used to sort this information out so that one luminance signal and two consistent chrominance signals are always available. There is one sprocket hole on the film per television field so that if 35mm film is used, the film is consumed at a rate of 56 ft/min. Field recognizer marks are shown on the film in Fig. 1. These marks might be used to provide a check on switching phase. Since the film is driven by a synchronous motor, however, they have been dis-

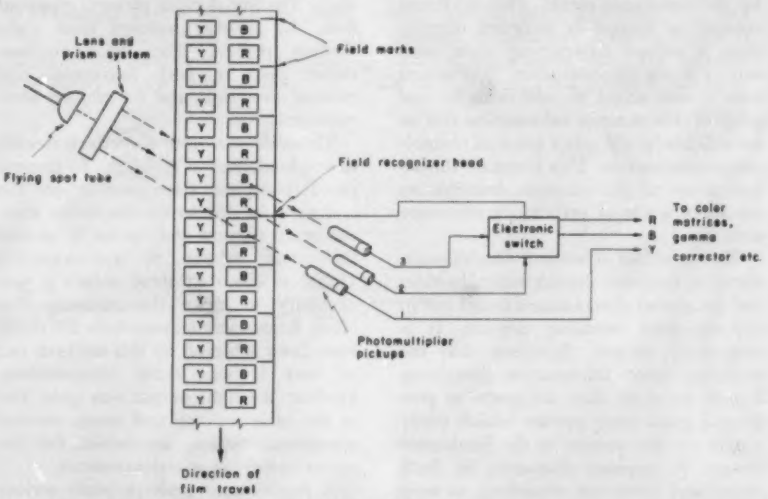

Fig. 1. Continuous film scanner for color television (first type).

* (1) "Feasibility and technique of storing color video information on black and white film," presented at 1954 National I.R.E. Convention; (2) "Experimental equipment for recording and reproducing color television images on black-and-white film," presented at 1955 National Convention of I.R.E. and at Chicago Convention of SMPTE (published in I.R.E. 1955 Convention Record, Part 7 — Transmitters, Receivers and Audio, pp. 69–80); (3) "A new recording method for color TV using black-and-white film," presented at Pacific Coast Convention of A.I.E.E.

Presented on May 4, 1956, at the Society's Convention at New York, by William L. Hughes, Engineering Experiment Station, Iowa State College, Ames, Iowa.
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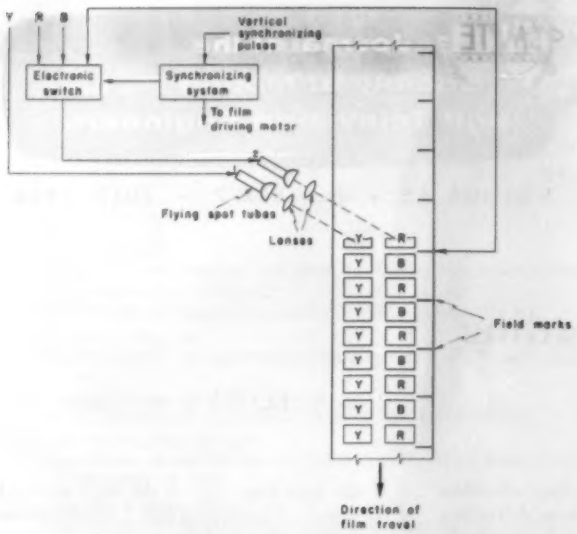

Fig. 2. Continuous-motion kinescope recorder for color television.

pensed with in the initial experimental model. Once the film is started correctly, it stays in proper switching sequence unless some external cause disrupts it.

The possibility that color fringing might occur during fast motion has been mentioned at various times. It is not likely that this will be objectionable. If it does become a problem, however, a relatively simple modification of the basic switching and scanning scheme will eliminate it. This modification is discussed in detail in one of the previous papers and will not be further elaborated on here.

A possible type of kinescope recorder is illustrated in Fig. 2. Here the unexposed film is moved continuously at a synchronous rate. The lefthand column of images is recorded directly from a cathode-ray tube with a single line or compressed raster. The tube is modulated by the luminance signal. The righthand column of images is recorded directly from a second cathode-ray tube with similar sweep characteristics. This second tube is modulated on odd fields by one piece of chrominance information and on even fields by the other piece of chrominance information. This alternate throwing away of chrominance information results in a loss of vertical chrominance detail.

The total loss of vertical chrominance detail is, however, considerably less than the horizontal chrominance detail lost in the standard encoding process. It is reasonably certain, therefore, that the resulting color information remaining should be more than adequate to produce a good color picture which really hinges on the quality of the luminance image. It appears desirable, in both direct and kinescope recording, to keep as much of the luminance information as possible coming from the luminance image and as little luminance information as possible coming from the chrominance images.

Initial Operation of the Experimental Scanner

An experimental model of the previously described scanning system was first put in operation late in 1954. It used a 5ZP16 scanner tube with a single-line scan (no vertical raster). A test pattern film was made to use with the scanner and to evaluate its capabilities. The individual images on the test film were approximately 4.75 mm high and 10 mm wide. This width is standard for a regular 16mm frame. The definition in both horizontal and vertical directions on the film was more than adequate to provide a very good television picture. Getting that information off the film, however, presented certain complications. The initial color pictures obtained from the scanner suffered from some obvious defects. The definition was rather poor in both horizontal and vertical directions, and the pictures were quite noisy.

These defects were directly traceable to one fundamental problem. To prevent rapid phosphor deterioration on the scanner tube due to the single-line scan, the beam current was cut to 10 μa and the ultor voltage to approximately 15,000 v. Even at these values it was necessary to move the scanning line often. Reasonable scanner-tube life could have been achieved by this method, but at best it was quite inconvenient. Further, the light output was quite low at the ultor voltage and beam current mentioned, which accounted for the objectionable noise characteristics.

A further and perhaps more serious difficulty was that at the low ultor voltage the scanner tube would not focus well enough to give a really high definition image. Still another and even more fundamental problem occurred which caused considerable degradation in the vertical definition of the reproduced image. The image on the film was compressed to a little over 0.6 of the height of a normal 16mm image. Even though this allows good vertical definition as far as the film is concerned, the spot of the scanner tube is essentially round and therefore discriminates against vertical detail as compared to horizontal detail in a vertically compressed image. This can be corrected by either using a much smaller scanner spot (which is not a particularly practical solution with present scanner tubes) or by optically compressing the scanning spot in the vertical direction.

To get an idea of resolution obtainable by compression of the scanning spot, let us choose a few numbers regarding resolution that might be expected from film and from a television scanning tube. A rather conservative figure for film resolution that might be expected under field conditions is 100 television lines/mm. This is equivalent to 50 photographic lines/mm. An image with a height of 7.5 mm then would be capable of about 750 lines. If this is scanned with a scanner tube with 600-line definition (ignoring for the moment that we only have 500 or so usable lines in the television display), the resulting definition would be about 470 lines.

Now let us suppose that we have a film image 4.75 mm high which is scanned with a spot that is compressed vertically by a factor of 6:1 or so. The resultant definition capability of the film alone is 475 lines, but the scanning system is capable of reading out essentially all of that definition; provided, of course, that there are more than 475 scanning lines in the first place. In other words, we can increase definition either by increasing film area or by decreasing equivalent scanning aperture size. It is true that the limiting definition of the 7.5-mm image would be improved by using the compressed spot. However, we begin to enter the area in which the absolute upper working limit is controlled to a greater and greater extent by the television scanning standards.

There is one other factor regarding vertical resolution in a video signal that is worth considering. Essentially all of the vertical resolution present in the video signal usually does reach the grid of the picture tube in the home receiver. Further in a properly focused receiver, the vertical resolution displayed exceeds horizontal resolution displayed because of the transmitter and receiver band pass characteristics. It is probably much less desirable to degrade horizontal resolution even by a small factor than it is to degrade vertical resolution by the same

factor as long as vertical limiting resolution still exceeds horizontal.

Design and Use of Compression Optical Systems

From the preceding discussion, and from the experience gained in the initial operation of the scanner, several things were successively apparent. To get good focusing characteristics and a high light output from the scanner tube, much higher values of beam current and ultor voltage were required. Therefore, the use of a single scanning line was not feasible because of the rapid phosphor deterioration. If a raster was required on the scanner tube, then some sort of compression optical system was needed to get the proper image aspect ratio as well as to improve vertical resolution characteristics.

As has been implied, it is not necessary to compress the raster vertically until it is approximately the height of a normal single line. As a matter of fact, if the vertical raster is compressed to about 1/26 of the normal raster height, the net result is to eliminate the area on the film that would normally be black during the vertical blanking period. Thus the film is used with absolute minimum waste area. In practice, a compression of 10:1 or more gives a perfectly satisfactory aspect ratio and the result is essentially undistinguishable from the ideal compression figure.

It is necessary to arrive at some compromise between electronic raster compression and optical raster compression. If compression is completely electronic, there is a loss in vertical definition for reasons explained earlier; and it is quite likely that the life of the scanner-tube phosphor will be shortened. On the other hand, it has proved impractical to get all of the required compression optically and still use cylindrical lenses of reasonable cost.

Still another factor must be considered. If such a device is to become commercially practical, it is probably necessary that the system be capable of showing still frame pictures. If good vertical definition is to be available in these still frame pictures, the spot must be compressed vertically by a factor of about two to one. Also the resultant image of the scanner tube on the film must have a proper television aspect ratio. Since the picture image on the film is compressed by a factor of about 0.6, then the image of the cathode-ray tube on the film is approximately 0.6 times as high as it would be if it were scanning a standard 16mm film image. The raster on the scanner tube then must be 1.2 times as high as it would be if it were scanning a standard 16mm film. This allows for the desirable 2:1 compression in the vertical direction which is obtained optically. The width of the raster on the scanner tube has been nominally about 4 in. This width gives good horizontal definition, and it is desirable to avoid sacrificing this feature. The height of the raster for still frame pictures is then 3.6 in. A little corner trimming occurs on a 5-in. scanner tube with this raster height, but this probably can be ignored for still frame purposes.

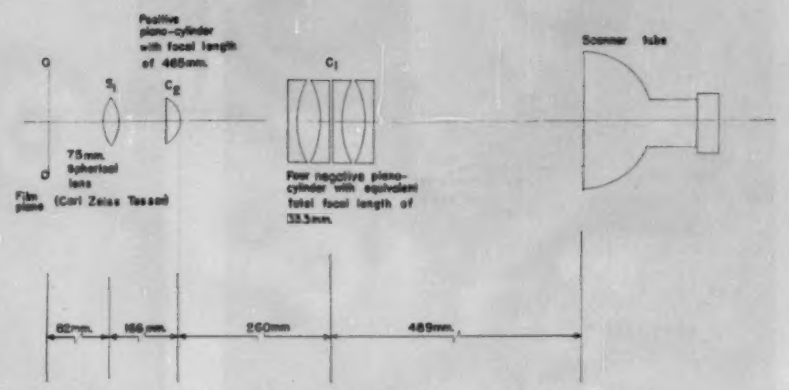

Fig. 3. First type of compression optical system (film running).

For running film, it appears that optical systems with a vertical compression of 6:1 can be designed with nominal complexity. Beyond this figure the optical systems either get quite complex or have too great a light loss. The remaining theoretical compression of 4.33 (26 divided by 6) can be obtained by electronic compression of the raster; although it has been found that 2:1 or greater electronic compression is quite satisfactory. If any objectionable overlap of successive fields occurs at the top or bottom of the picture, it is easily removed by reversal of vertical sweep direction on the scanner tube, and the resulting aspect ratio distortion is insignificant.

From the preceding discussion, the requirements of a practical optical compression system can be stated:

(1) It should have a vertical compression of 2:1 for still frames.

(2) It should have a vertical compression of about 6:1 for running film.

(3) In addition, when switching from running film to still frame, it is necessary to disable the electronic switch and increase the size of the vertical sweep.

The first compression optical system that was used is shown in Figs. 3 and 4. Figure 3 shows the arrangement of the optical elements when the film is running. Its operation is described briefly as follows: The negative plano-cylinders, C_1, produce a virtual image (vertical only) of the scanner-tube face approximately 31 mm to the right of their geometric center. The single positive plano-cylinder, C_2, has a relatively long focal length. The distance from C_2 to the virtual image produced by C_1 is considerably less than the focal length of C_2. The net result is that C_2 forms a second virtual image (in the vertical only) at the face of the scanner tube. The height of this second virtual image is $\frac{1}{6}$ of the height of the actual raster. Thus, the spherical Tessar lens "sees" a raster of normal horizontal dimension but with the vertical dimension compressed 6:1.

Figure 4 illustrates the optical configuration when the film is not running. The only thing that is changed is that the negative cylinders are removed, and two positive plano-cylinders, C_3, are inserted in another position which is closer to the scanner tube. The function of C_3 is to form a real image of the scan-

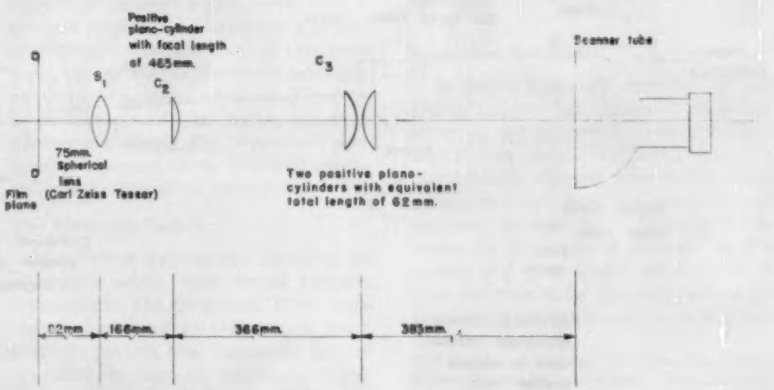

Fig. 4. First type of compression optical system (film stopped).

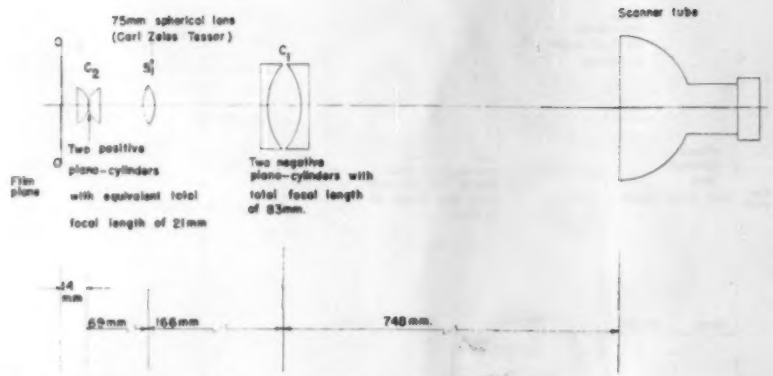

Fig. 5. Second type of compression optical system (film running).

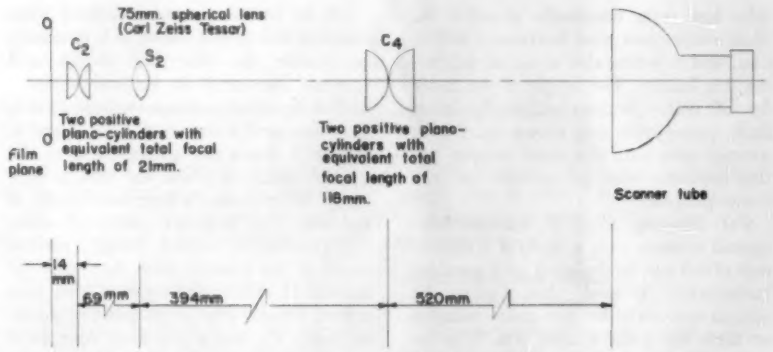

Fig. 6. Second type of compression optical system (film stopped).

ner-tube face (vertical only) at the same position as the virtual image of the negative cylinders which were removed. The remainder of the optical system can then be left alone. This configuration gives the net compression of 2:1, which is required for still film.

The overall system was satisfactory in every respect for still film. The compression characteristics and optical image quality were quite satisfactory for running film. There was, however, an overall light loss in the system of about 6:1 for running film. The basic reason for this light loss can be explained from a fundamental rule of optics. It is not possible to increase the radiant flux per unit area per steradian of solid angle. This means that to place a compressed raster on the film with the same radiant energy as a normally uncompressed raster, it is necessary to increase the lens aperture or make provisions for an auxiliary lens closer to the film. There was, of course, a considerable increase in the light output of the scanner tube due to the higher ultor voltage and beam current. This increase very roughly made up for the light loss in the compression optical system. The overall results, therefore, were that image quality and definition were much improved, but the noise characteristics remained about the same.

The noise problem was largely overcome by using a scanner tube with considerably more total light output than the 5ZP16. That tube is the 5AUP24 which is mainly used for color film flying-spot scanners and has a relatively wide band spectral output. This characteristic is, of course, relatively unimportant when used with a system of the type discussed in this paper. The phosphor correction requirements for the 5AUP24 are somewhat more severe than those of the 5ZP16, but the light output is sufficient to overcome this disadvantage and still have a light advantage over the 5ZP16 of perhaps 4:1 or more. The overall noise characteristics are satisfactory with this arrangement, but there is not enough leeway to allow for losses that invariably occur when such devices are used in commercial applications instead of in a development laboratory.

A safety factor can be built into the equipment rather easily by redesigning the optical system. Figures 5 and 6 illustrate a new compression optical system which performs the same geometrical functions as the original system, but is between two and three times as efficient. Figure 5 illustrates the system for running film.

The operation of the second optical system is as follows: The two negative cylinders, C_1, produce a virtual image (vertical only) approximately 75 mm to the right of C_1. The 75-mm spherical Tessar lens produces a real image (of the virtual image of C_1) approximately 25 mm to the left of the film plane. The function of the two positive plano-cylinders, C_2, is to move the vertical image of S_1 back to the film plane. The overall compression of this system is 6:1 over the image reduction effect of the 75-mm spherical lens alone. Figure 6 illustrates the system for the film stopped. The only change is that the negative cylinders have been removed and two

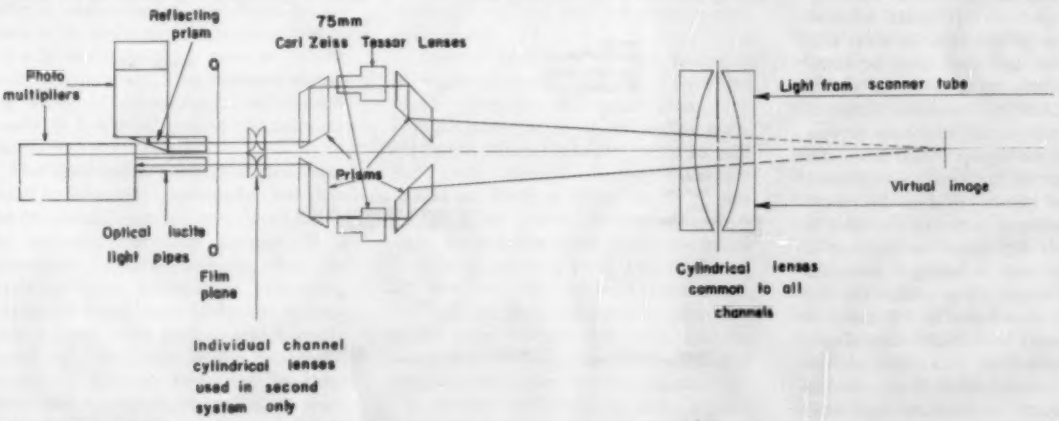

Fig. 7. Light paths for chrominance channels.

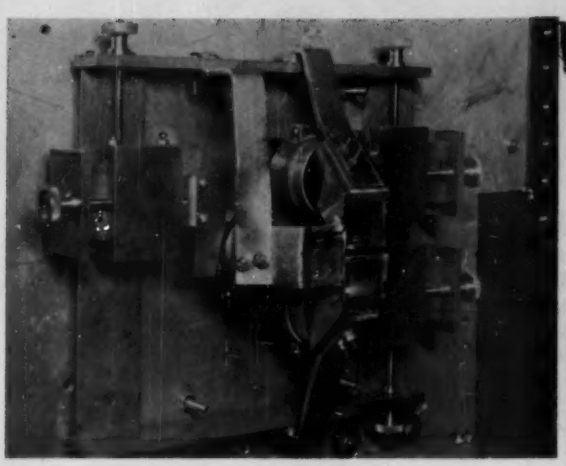

Fig. 8. Lens mounting.

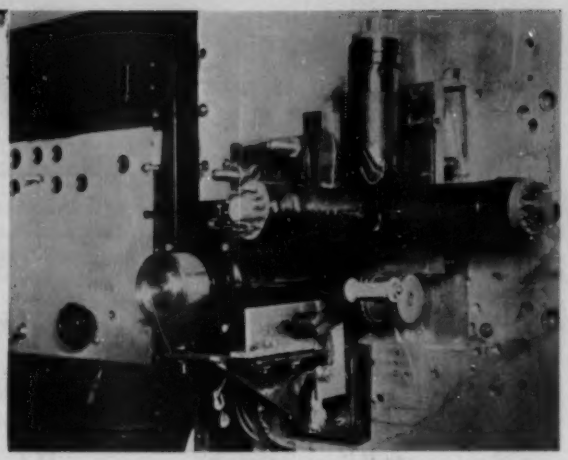

Fig. 9. Film transport mechanism.

positive plano-cylinders, C_3, have been inserted at the position shown. The function of C_3 is to produce a real image (vertical only) in the same place as the virtual image produced by C_1 when the film is running. The overall vertical compression beyond the image reduction effects of S_1 alone is 2:1.

This second optical system has been built and operated successfully. High resolution pictures which are essentially noise free have been obtained through its use. It is expected that there will be no further need to increase the system light efficiency.

For purposes of clarity, it should probably be mentioned that the optical systems illustrated in Figs. 3 through 6 are shown for only one channel. In the actual system, the cylindrical lenses in front of the spherical Tessar lenses are made physically quite large. It is thus possible to split the light for each Tessar lens by using rhomboid prisms and to use the same cylindrical lenses for all three channels. In the second optical system described, the positive cylinders, C_2, must for physical reasons be very small, and thus, one complete set of them must be used for each channel. Figure 7 illustrates how the light is split for the two chrominance channels. The luminance channel is left out for clarity. Figure 8 is a photograph showing the mounting of the lenses and three of the rhomboid prisms.

(At the oral presentation of this paper, a number of color slides of color television pictures produced by this system were shown. Some of them showed "before" and "after" characteristics of the system for some of the difficulties which have been overcome.)

Film-Transport Mechanism

One of the more serious problems often encountered in continuous motion systems is the difficulty of obtaining sufficient stability in the film transport mechanism. A number of elaborate systems have been built which use moving optical systems and feedback loops to position the scanning raster in agreement with the film position. It was considered desirable to avoid these complications if possible. A number of simple transport mechanisms have been tried.

In this experimentation, it has been found that the stability of a small synchronous motor-reducer combination can be made with adequate stability. A difficulty arises, however, in getting the same stability in the film gate. The current transport mechanism (and the best one obtained thus far) consists of a standard Simplex film trap assembly that has been machined to make provisions for mounting the three photomultipliers and their associated optical lucite light pipes and prisms. A Bodine synchronous motor-reducer with a drive sprocket mounted on it is placed directly beneath the Simplex film trap. The stability of this mechanism compares reasonably well with the stability of the average 16mm motion-picture projector and probably would be adequate for television broadcasting with films of moving objects. A system for kinescope recording would have to be somewhat better. It is quite possible, however, that the film could be recorded directly on a drive sprocket assembly and would not have to go through a gate, since there is no need to gather the light into a photomultiplier behind the film. If this were done, the stability of the motor assembly alone might be quite adequate. Figure 9, a photograph of the entire transport mechanism, shows the photomultiplier housing mounted on the film-trap assembly and the film-drive mechanism.

The Electronic Switch

In previous papers, the circuit of an electronic switch that would perform satisfactorily was presented. There were eight adjustments in this switch. Each time the switch was balanced, it was necessary to use an oscilloscope and check each of the eight adjustments. In recent months the General Electric Co. has manufactured for electronic switching purposes a new tube designated 6AR8. Basically, it is a multi-grid tube with beam deflecting electrodes and two anodes. Either anode can be selected, depending on the potential applied to the beam deflecting electrodes. The valuable feature of the tube in this application is that its transconductance is essentially independent of the anode being used. This means that when one channel is dynamically balanced, the other must be also.

If two of these tubes are used as shown in the electronic switch circuit of Fig. 10, only four adjustments (two d-c and two dynamic) are necessary. Further, if the two tubes are once balanced d-c wise and sufficient low-frequency degeneration is introduced, the little d-c drift which occurs is easily removed by the keyed clamping circuits. When one of the dynamic adjustments is set to some medium value, the entire electronic switch can then be balanced by the other dynamic adjustment. This means that it can be rebalanced visually without using an oscilloscope while the film is running should some severe change in gain occur in a chrominance channel. Thus, no shutdown of the equipment is necessary.

Kinescope Recorder

As yet, a kinescope recorder for this system has not been built. A kinescope recorder for black-and-white television which has similar problems (i.e., a continuously moving film and a compressed vertical raster) has been built and operated successfully in England.* The optics for a kinescope recorder in this system are quite simple since the light does not have to be gathered behind the film after passing through it. It is hoped

* V. B. Hulme, "16mm Television-recording for sequential television systems," *Electronic Eng.*, 516–522, Dec. 1955.

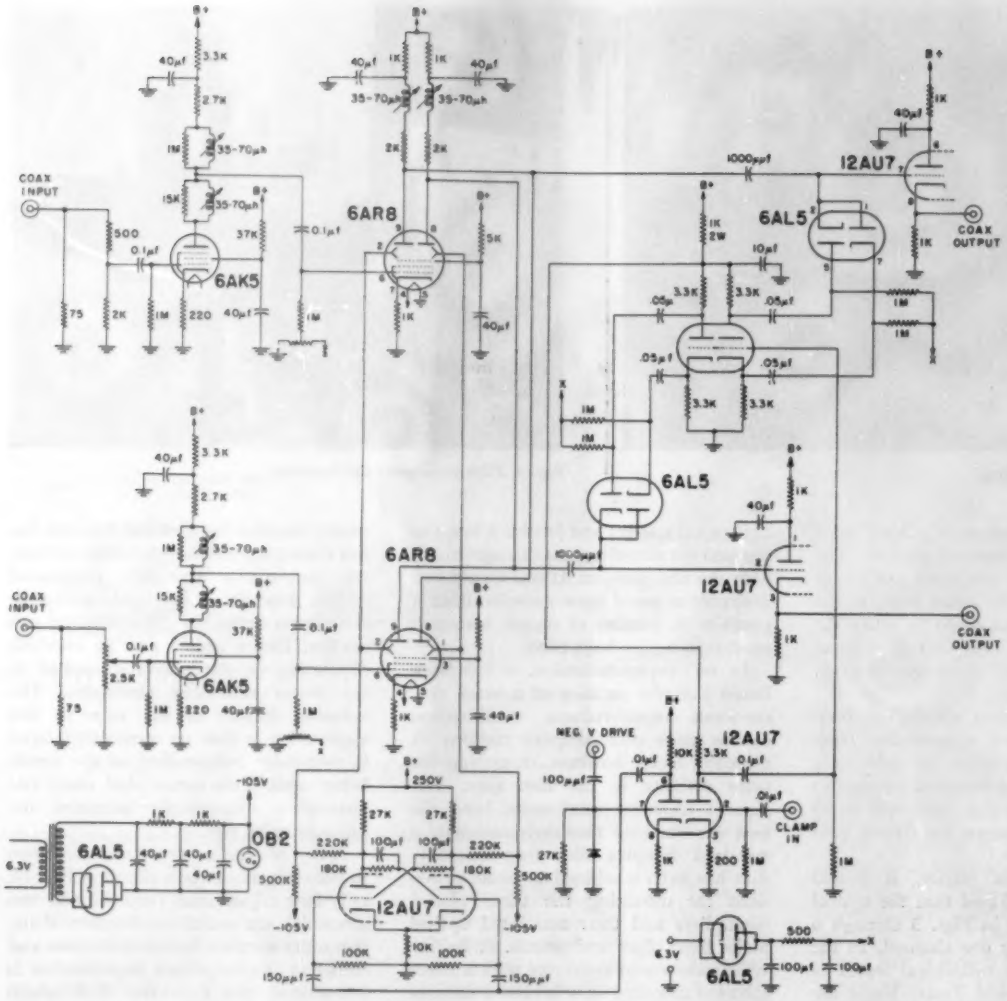

Fig. 10. Electronic switch.

that this work might be undertaken in the near future.

Conclusions

It is believed that the principles upon which this device operates are sound and that good quality color pictures can be obtained from it. Further the versatility of this system in doing all television jobs would seem to be a great advantage. Also, the amount of black-and-white film used per minute is a little over half that used by other systems of this general type.

The writer is indebted to many people for assistance in this project. In particular, Paul Kristensen of Iowa State College has lent considerable help. Assistance with the optical system has come from Arthur Cox, Optical Director of Bell & Howell Co., and from Larry Iverson and Albert Anderson of Benson Optical Co. in Ames, Iowa, and Minneapolis, Minn., respectively.

Discussion

Anon: What type of film was used for the color slides?

Mr. Hughes: The film we used was the new, fast Ektachrome. I must hasten to add that I've gotten very nice results with Ektachrome in normal photography, it's just that we apparently, at Iowa State, don't know how to use it for photographing dichroic displays.

Anon: I gather that the slides must have been photographed right from the television?

Mr. Hughes: Yes. We have a Graflex 2¼ by 3¼ camera mounted right on the dichroic display and whenever we want to take a picture we just let fly.

Anon: Got some excellent results with my Bolex right from an RCA 21-in. color set.

Mr. Hughes: What film did you use?

Anon: Anscochrome.

Skipwith W. Athey (Chairman): I think that what you're getting at here is a process which is pretty much of a lottery. One can get good results with all films from all sources but not under all conditions. And I think you were lucky. I think that if you went to another tube, to another day's production on a particular tube, you wouldn't get the same result. But I believe there's not very much you can make in the way of a positive statement without going into detail.

Mr. Hughes: I think a lot of people, like Goodale at NBC, have done some excellent color recording. It can be done very well on most stocks, but you have to know how to do it, and we don't yet.

John P. Muller (WDSU-TV—New Orleans): Would this system necessitate a new system of projection?

Mr. Hughes: The system itself is of course entirely nonstandard. Now what this would involve is a simple transport mechanism, in other words a motor of the type we showed, plus the electronics and the pickup head. The rest of course would multiplex right into the regular color system. We believe that a short rack of electronics and a console, about 2 ft square and 4 ft high, would multiplex into the regular color system.

Mr. Muller: Transmitting right over the TV system?

Mr. Hughes: That's correct, the idea being that one could go out with his mechanical camera and make his new shots or whatever he's shooting, bring it in and process it, put it all on his scanner, run it right through the encoder, and out through the transmitter.

Color Kinescope Recording on Embossed Film

By C. H. EVANS
and R. B. SMITH

In the past, a special form of black-and-white film, with tiny cylindrical lenses embossed in its base, has been employed in conjunction with a banded color filter for additive color photography. Such film is readily adaptable to color kinescope recording, and in this application the banded filter is not required. Color aspects of the problem can be left to the television system. The advantages of color kinescope recording on embossed film include economy, faithful color reproduction, high efficiency and rapid film processing. The latter is particularly important in meeting the demands of time-zone-delayed broadcasting, or "quick kine." Prints for subsequent distribution can be made on ordinary subtractive color films.

IN BLACK-AND-WHITE television, kinescope recording has become essential to network operation. It is the basis of time-zone-delayed rebroadcasting and it provides both the means of using the program again at a later date and of making the program available to stations not tied in with the network during the original broadcast.

At present, there is no commercial method of color kinescope recording. Some degree of success can be attained by photographing a color-television monitor on regular color negative materials. This solution is not completely satisfactory, partly for reasons of cost and quality, but primarily on account of the complexities of color development and the time required for processing. For time-zone-delayed rebroadcasting, the processed film must be ready for projection less than three hours after exposure.

The present paper describes a color kinescope recording method capable of meeting the requirements. This method employs embossed 35mm film, coated with a black-and-white type of emulsion. It has been demonstrated at the Kodak Research Laboratories to the management and key technical people of the television networks, as well as to manufacturers of broadcast equipment in the television industry. Because the film is of the black-and-white type, it can be processed quickly and easily, right at the network station, if so desired.

Color Photography on Embossed Film

The principles of additive color photography on embossed film are well known, and similar principles apply to kinescope recording on this material. To facilitate the description of the proposed color kinescope recording process, the manner in which embossed film can be used for direct, additive color photography will first be reviewed.

Embossed 35mm motion-picture film has small, cylindrical lenses, called "lenticules," embossed in its base. Each lenticule has its long axis perpendicular to the edge of the film, and extends all the way across the 35mm width. There are 25 transverse lenticules embossed in each millimeter of film length, making each tiny cylindrical lens about 0.0016 in. high. As shown in Fig. 1, the film is loaded with its base toward the camera lens, so that light entering the camera must travel through the lenticules before striking the light-sensitive emulsion. The camera lens is shown schematically as a simple, single element, but actually a multi-element photographic objective would be used. Upon development, the film emulsion yields a colorless silver image. For the present, we shall assume that reversal processing is employed, so that the developed image will be in the form of a positive.

A banded color filter acts upon the light passing through the camera lens, the actual position of this filter depending upon factors which include the optical design of the particular lens employed. The long dimension of each filter band is placed parallel to the lenticules. At the top of Fig. 1 is a view of a four-banded, three-color filter, as it appears from the optical axis. The blue filter is split into two parts to reduce vignetting problems. The object being photographed is imaged upon the film by the camera lens, while the colored bands of the filter are imaged by each lenticule onto the emulsion area lying directly behind it. To keep the schematic representation used in Fig. 1 as simple as possible, the subject is shown to be imaged upon the first surface of the film base. In practice, however, the best focus position should always be determined by photographic tests. At optimum, the focal plane of the objective actually lies within the film base. As a further simplification, the light is shown passing through only one lenticule, although in the height of a 35mm motion-picture frame, there are about 390 lenticules, each forming its own individual image of the banded filter.

It is easily seen that the function of the banded filter is two-fold. In the first place, by the spectral properties of the filter bands, it makes three color-separations (red, green, blue) of the light coming to it from the subject. These separations are, in principle, like those made in a color-television camera by means of dichroic mirrors and trimming filters. In the second place, by the geometrical form of the filter bands, acting in cooperation with the lenticules, the filter directs these separations to different areas of the emulsion layer. Thus, three color-separation records in black and white are made on a single frame of film. They are laid down in proper register, and remain in register, despite any reasonable subsequent dimensional change in the film, such as might be caused by ordinary film shrinkage. The optical image of the subject is divided into a number of horizontal strips, corresponding to the number of lenticules in a frame height, and each of these strips is subdivided into red, green and

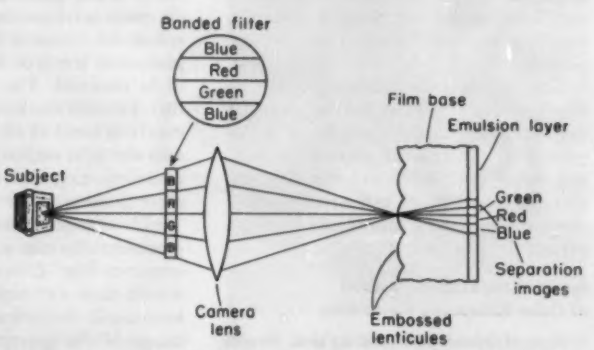

Fig. 1. Color-separation photography of natural objects, using embossed film.

Communication No. 1806 from the Kodak Research Laboratories, presented on May 4, 1956, at the Society's Convention at New York by C. H. Evans (who read the paper) and R. B. Smith, Research Laboratories, Eastman Kodak Co., Rochester 4, N.Y.
(This paper was received on May 14, 1956.)

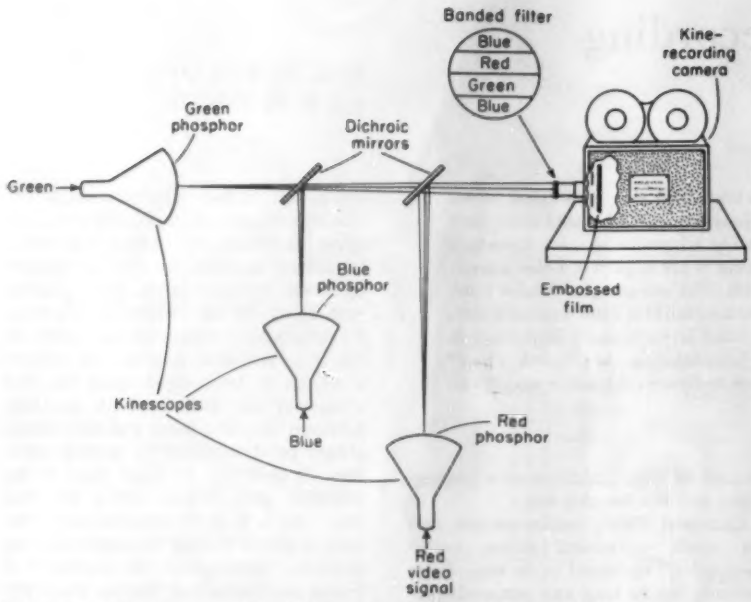

Fig. 2. Color kinescope recording by the spectral separation method.

blue components. It is to be noted that the emulsion must be sensitized panchromatically in order to record blue, green and red light.

Projection of a color picture recorded in black and white upon embossed film is essentially the inverse of the recording process. If we imagine the direction of light travel in Fig. 1 to be reversed, then this figure illustrates the projection process. The film, developed by reversal to a positive image, is placed back in the optical system in the identical position it occupied during exposure. White light is directed upon the film from the right and is acted upon by the developed silver images before being projected toward the filter bands by the lenticules. Light transmitted by the red-separation record, for example, strikes the red filter only. Up to this point the light has the color of the source, but in the red filter the light becomes colored red by absorption of green and blue. After passing through the filter band, the red light continues on to the screen, where it forms an image corresponding to the red portion of the subject originally photographed. Green and blue images are formed similarly, resulting in an additive three-color picture.

Loss of light by absorption in the filters during projection has constituted a major obstacle in the application of this process to professional motion pictures, but as we shall see later, this difficulty can be avoided in television because there the projection filters can be eliminated.

Spectral Separation Method of Color Kinescope Recording

A method very similar to that shown in Fig. 1 can be used for color kinescope recording, as shown in Fig. 2. In this case, color information comprising three signals in a color-television system is recorded on embossed film by using a red-, a green-, and a blue-emitting kinescope in conjunction with a banded filter placed over the camera lens. In spite of the similarities, an important difference exists between this system and that shown in Fig. 1. In the kinescope recording system of Fig. 2, the banded filter no longer performs the function of separating the light from the subject into red, green and blue components. The subject is now in front of the television camera, and the primary task of color separation is performed by the television system. The red, green and blue colors of the kinescope screens and of the filter bands merely ensure that the three pieces of color information are optically separated, and individually recorded in recoverable form by virtue of being directed to different areas behind the lenticules.

Although the figure shows the information from the "red" channel being fed to a red-emitting kinescope, and so on, there is no necessary relationship between the colors of the kinescope phosphors and the type of color information to be recorded. The sole requirement is that, for each kinescope, there must be at least one band of the filter which transmits the light emitted by that kinescope, while rejecting the light emitted by the other kinescopes. Thus, for example, the "red" channel information could be presented via the green-emitting kinescope of Fig. 2, and this information would then be recorded behind each lenticule in the area which constitutes an image of the green band of the filter. Further, the information presented on the kinescopes does not even have to be in the form of "red," "green" and "blue" separations at all. It would be possible to use the television "I," "Q" and "Y" signals, or other forms of color information, and they would still be recorded in individually recoverable form. Likewise, other colors than red, green and blue could be employed in the kinescopes and filter bands.

This may be referred to as "the spectral separation method," because, at the filter, the light emitted from each of the kinescopes is separated from the light emitted by the other two kinescopes on the basis of their spectral distribution of energy. The method is wasteful of light, because the filters are inefficient. Furthermore, the film emulsion must be optically sensitized in order to record the different colors of light.

However, because the task of color separation has already been performed by the television system, before the final record is made on embossed film, it is not necessary to employ a banded filter over the camera lens.

Geometrical Separation Method

The banded filter can be dispensed with in color kinescope recording if other suitable means are devised for separating the light from the three kinescopes. As shown in Fig. 3, the requirements for placing the three color records in the proper positions behind the lenticules can be met by photographing each kinescope through an appropriate aperture which replaces the corresponding filter band. Thus, the color-separation image appearing on one of the kinescope screens is photographed through a clear aperture corresponding in size and position to the red band of the filter, the second separation through an aperture corresponding to the green band, and the third separation through a divided aperture corresponding to the blue filter bands. This is referred to as "the geometrical separation method," because no filters are used, and separation of the light from each of the kinescopes is accomplished purely on the basis of the geometry of the system. It follows immediately that when this method is used, the kine-

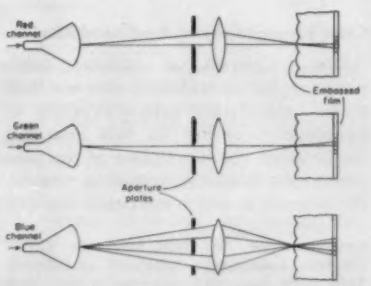

Fig. 3. Recording three existing color separations on embossed film by means of unfiltered apertures.

scopes no longer need to be differentiated in color among themselves.

The geometrical separation method has distinct advantages over the spectral separation method. It permits sharp optical separation of the light from the three kinescopes, at high efficiency. In systems requiring filters, there is a loss of efficiency because light from each of the three different phosphors spectrally overlaps the light from one or both of the other phosphors. In order to obtain clean separation by filters, light corresponding to the overlap regions must be eliminated. Moreover, a filter always absorbs some of the light in its passband. In a geometrical system, all three kinescope screens can be composed of the same type of phosphor, and this can be chosen solely on the basis of its suitability for kinescope recording.

Just as in ordinary, black-and-white kinescope recording, the phosphor chosen should have a short decay time and should have its chief emission in the blue or near-ultraviolet regions of the spectrum. The latter condition permits using blue-sensitive film, which can be handled under relatively bright safelights. A further advantage of the geometrical method is that it avoids the problem of matching photographic gammas in different regions of the spectrum, because all three of the separation images are exposed by light of the same spectral quality.

A practical means of applying the geometrical separation method to color kinescope recording in a simultaneous television system is shown schematically in Fig. 4. Here, the apertures in the "red" and "green" channels of Fig. 3 have been replaced by two silvered reflecting faces of a prism placed in front of the camera lens. The "blue" apertures are now defined on their inner edges by the edges of the prism, and along their outer edges by means of a diaphragm. The central portion of the beam from the "blue"-channel kinescope is absorbed by the blackened rear surfaces of the prism. In the apparatus shown, a collimating lens is used in each of the three optical paths, thus placing the silvered prism in collimated light. The two optical paths utilizing the mirror faces of the prism are folded before reaching the collimators in order to place the kinescopes farther from the camera, and these optical paths are brought into the prism at angles of less than 90° with the axis of the camera lens. This serves the double purpose of minimizing interreflections between the collimators, and of bringing the two mirror faces to lie more nearly in a plane.

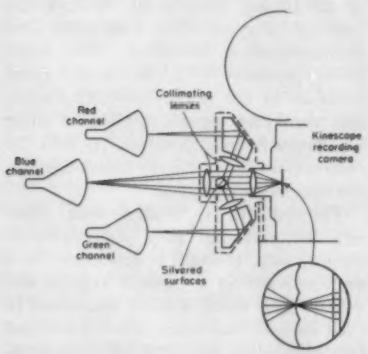

Fig. 4. Color kinescope recording by the geometrical separation method.

For reasons which will be discussed later, the prism is placed at the front focus of the camera lens. This lens must be focused at infinity, because it receives collimated light. The entire optical assembly superposes in register, on a single frame of the film, the three separation images appearing on the kinescopes. At the same time, the effective apertures of the three optical paths from the individual kinescopes are geometrically separated, as seen from the film lenticules, and thus the light from each channel is separately recorded in the proper area behind each lenticule.

Tests made on an experimental unit of this type have demonstrated the soundness of the method. A simplified and improved model without collimators is now under development at the Eastman Kodak Co. In order to realize the full capabilities inherent in the system, a special camera objective lens will be employed.

Televising Embossed Film

Special optics are required for televising embossed-film color records, but basically any of the common means of televising motion-picture film may be used. An example of a system employing a flying-spot scanner is shown in Fig. 5. Here, the emulsion side of the embossed film faces the scanning tube, with the scanning spot focused sharply on the emulsion. The light which is transmitted by the black-and-white recorded color separations is then projected by the lenticules in bands corresponding to the apertures of the taking unit. These bands are focused by a lens into a plane which may be called the "plane of separation." At this plane, light from each of the three individual color records falls into its own separate and distinct area. Therefore, it is a simple matter to devise optics which will pick out the light from each of the color records and direct it to a suitable transducer. Figure 5 indicates schematically how this could be done in the case of a flying-spot scanner by means of mirrors placed at the plane of separation. In practice, we have employed a set of four prisms, or integrating bars, instead of mirrors. These are arranged so that their entrance faces lie right in the plane of separation, each

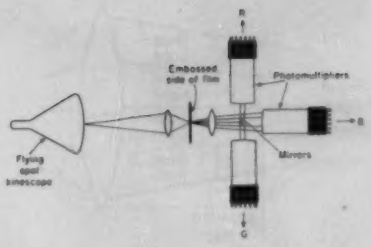

Fig. 5. Televising embossed film by means of a flying-spot scanner.

coinciding with one of the bands of light formed there. The exit face of each integrating bar is placed next to the photocathode of one of the three end-on photomultiplier tubes. Two integrating bars are required to pick up the light in the "blue" channel, because a two-part aperture was used in recording this portion of the color information, and both of these bars are directed toward a single photomultiplier tube. To ensure efficient collection of the light, all except the entrance and exit surfaces of the integrating bars are silvered. A set of integrating bars is shown in Fig. 6.

Use of a continuous projector and flying-spot scanner in conjunction with the embossed-film process eliminates difficult color-registration problems in the projection link of a television chain, while retaining the advantages of an additive system. The optical efficiency is high, because no filters are required in the television projector and the spectral sensitivity of the photomultiplier tubes may be chosen to match the characteristics of the source.

If it is desired to reproduce a color-television picture from embossed film by means of vidicons or other storage-type tubes, then it is necessary to employ a different type of light-collecting system. Color-separation images of the subject must be formed and scanned on three storage surfaces, and this, of course,

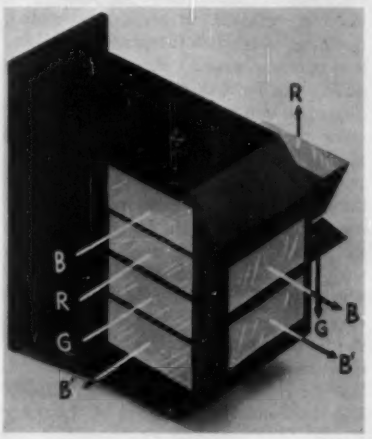

Fig. 6. Integrating bars used to collect light at the plane of separation.

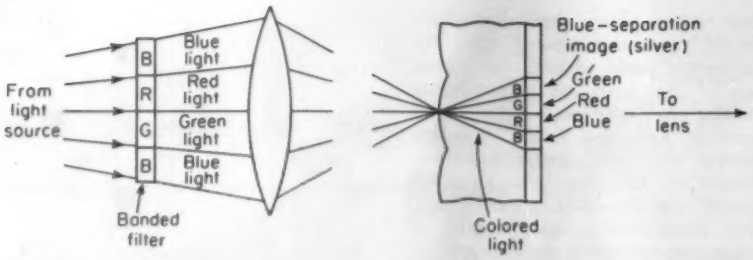

Fig. 7. Portion of an optical system employing a banded filter between the light source and the embossed film.

introduces a critical registration requirement which is both optical and electronic in nature. A possible system would operate in a manner inverse to that of the geometrical recording unit shown in Fig. 4.

Another approach to the problem of reproduction from embossed film by means of storage tubes is similar to that employed in ordinary projection from such film. For example, an intermittent type of television projector, having the conventional tungsten light source, can be fitted with a banded color filter placed in front of the projection lens. In the absence of intervening optics beyond this point, a colored picture will be formed at the plane upon which the projector is focused. This picture may then be relayed through a system of lenses and dichroic mirrors which will again sort out the red, green and blue light and form the color-separation images on the three storage surfaces. In a variant of this scheme, the dichroics could be interposed between the banded filter and the plane upon which the projector is focused, in which case the separation images would be formed directly, without the prior formation of a fully colored picture.

In any arrangement employing a banded color filter over the lens, there is a loss of light. It appears that this loss can be tolerated in forms of television equipment having sufficiently high signal-to-noise ratio, such as those employing vidicons. It should be noted, however, that when filters are used there is a conflict between the efficiency with which the light is transmitted and the degree to which the light from the three color records is separated. Broad-band filters favor transmittance at the expense of full separation, while narrow-band filters aid clean separation at the expense of the amount of light available to the transducer. Another consideration with this type of system is that the aperture of the projection lens must be large enough to accept the cone angle at which the lenticules project the color bands, or else there will be a shift in color balance, leading in the extreme case to complete loss of the color represented by the outer bands.

This cone angle is about $f/2.3$, as will be discussed in a subsequent section of the paper. For the present consideration of projection techniques, it is interesting to note that there is another method of using a banded filter which places less stringent requirements on the projection-lens aperture. As shown in Fig. 7, the banded color filter may be placed between the light source and the film. In this case, the lenticules face the light source instead of facing the projection lens. The bands of the filter are so proportioned that each one is imaged by the lenticules exactly into the corresponding black-and-white color-separation record. In effect, this colors the separation image while it is in the projection gate. All of the separation images together form a three-color additive picture which may be projected in the usual manner, and the projection lens can operate at a considerably smaller aperture than the lenticules themselves. The demand for a high aperture is shifted to the illumination side of the film, requiring the use of a high-quality, large-aperture condensing system.

Making Copies From Embossed Film

In the commercial use of black-and-white kinescope recording by the networks, it is common practice to prepare 16mm prints for syndication, or release to stations not on the network during the "live" broadcast. These prints are televised at local stations which are equipped with various forms of 16mm projectors. To cover this same situation in the case of color kinescope recording, it will be necessary to prepare 16mm prints from the original 35mm records. It seems unlikely that any considerable number of local stations will be willing to invest in 35mm equipment when setting up apparatus for color-television broadcasting, and it is not desirable to use embossed film for television in 16mm form on account of the reduced number of lenticules per frame. Therefore, it appears that the copies required will be 16mm subtractive color prints.

An optical system used experimentally in printing directly from 35mm embossed film to a 16mm subtractive color film makes use of the principle already discussed in connection with Fig. 7. A banded color filter and a special condensing lens system replace the ordinary illumination system of the printer. The 35mm embossed film passes through the printer gate, with its lenticules facing the banded filter. While in the film gate, the interlaced color-separation records become colored, as explained in the discussion of the projector. This 35mm color picture is then imaged in reduced size upon the 16mm gate of the printer, where the print stock is exposed. The spectral transmittances of the filter bands are chosen with proper regard for the sensitivities of the print stock, and not for their visual effect. Prints have been successfully made in this manner, with an Acme reduction printer. The special illumination system employed had the same length as the regular system so that no modifications of the body of the printer were required.

According to the polarity of the signals applied to the recording kinescopes, and depending upon the choice of ordinary or of reversal photographic processing, the color-separation images recorded on the embossed film may be positives or they may be negatives. If they are negatives, the 16mm print stock would be of the positive type, such as Eastman Color Positive Film; if they are positives, a reversal film such as Kodachrome would be chosen.

A Color-Television Recording System

At this point, the principles of color-separation photography in black and white on embossed film have been described, and means of using this type of film to record color information derived from the subject by a television system have been outlined. Methods of extracting the information stored in the film have also been touched upon. The treatment has not covered all possibilities, nor has it been complete in detail, but the basic concepts have been developed.

To aid in visualizing the operation of a system for color kinescope recording on embossed film, a complete hypothetical system may be described as follows:

The recording equipment consists of an ordinary 35mm kinescope recording camera fitted with a special lens, and working in conjunction with some form of combining unit which utilizes the principle of geometrical separation. The three recording kinescope tubes have P-16 phosphor screens with peak emission in the near-ultraviolet region, and the video signals applied to these kinescopes have such a polarity that the color-separation images appearing on the screens are positives.

The camera is loaded with blue-sensitive embossed film. After the recording step, the film is developed for 4 or 5 minutes in a positive type of developer and fixed, washed and dried in the normal manner. The developed images are in the form of color-separation negatives.

By electronic reversal from negative

to positive, these original recordings are used for time-zone-delayed rebroadcast of the program. Synchronized magnetic recording film carries the sound portion of the program. After this use of the embossed-film negative, it may be used directly for preparing 16mm reduction prints on Eastman Color Print Film, Type 7382. A sound-recording negative suitable for printing on Type 7382 can be prepared by rerecording from the original magnetic track. The composite 16mm color prints can then be televised in the usual manner by local stations. Obviously, many variants of this system are possible. The details will have to be worked out to suit the convenience of the user.

Up to this point, the optical problems involved in the use of embossed film have been treated in a qualitative fashion. It will be recognized that the diagrams have been schematic for the purpose of explaining general principles. Full treatment of the optical details is beyond the scope of this paper, but some of the more important facts will be presented in the following section.

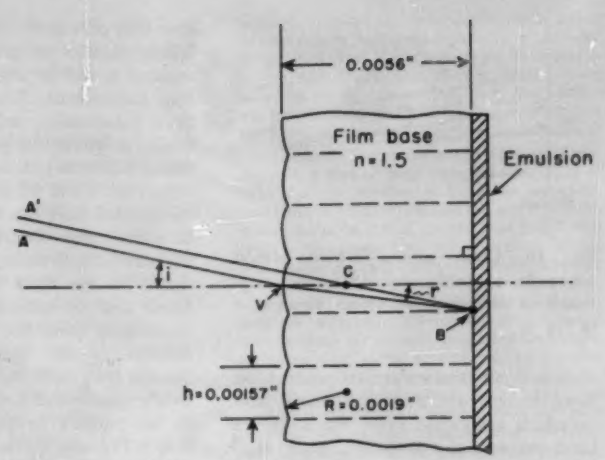

Fig. 8. Longitudinal cross-section of 35mm embossed film.

Optics of Lenticules

As a consequence of the extremely small size of the film lenticules in relation to the remainder of the optical system, the scale of the diagrams used in the preceding sections has generally been deliberately distorted. The focusing action of the lenticule has not been shown, but the paths of certain selected rays striking the vertex of the lenticule have been indicated. Figure 8 is drawn to scale, and shows some of the dimensions in a longitudinal cross-section of the film. There are 25 transverse cylindrical lenticules embossed in each millimeter of film length, making each one 0.00157 in. high. The active length of each lenticule is the same as the width of a 35mm motion-picture frame, or 0.816 in. in the case of a recording camera. The thickness of the film base is about 0.0056 in. Its index of refraction, and that of the gelatin carrying the photographic grains, may be taken as 1.5. The radius of curvature of the single active surface of each tiny lens is 0.0019 in., or one-third the thickness of the film. If we imagine a single lenticule to be scaled up to a more readily visualized size, say 1 in. high, then its thickness would be about 3.6 in. and its length about 43 ft.

In the diagram, the broken lines indicate the intersections of adjacent lenticules. Point *B* lies in the plane of intersection between two lenticules, and also in the plane of intersection of the film base and the light-sensitive emulsion layer. *V* is the vertex of the lenticule, at which point the curved surface is perpendicular to the optical axis. Light ray *AV* strikes the surface at an angle of incidence *i*, such that, after refraction at an angle *r*, it traverses the film base and strikes point *B*. The angle *i* may be found by application of the formula, $\sin i = n \sin r$, in which n and r are known. It is found that the tangent of twice the angle *i* is 2.3. This means that an *f*/2.3 cone of light striking the film perpendicularly at point *V* will just fill the height of the lenticule at the intersection between film base and emulsion.

Line *A'C* is drawn parallel to *AV*, through the center of curvature *C* of the lenticule. A light ray following the same path from *A'* would thus strike the lens surface perpendicularly, and would pass undeviated through point *C*. This ray intersects ray *AVB* at point *B*. In other words, light from an infinitely distant object is brought to a focus by the lenticule at the plane of the emulsion.

An important point to remember is that, on account of the very small size of a lenticule, an object just a few inches from the film is, for all practical purposes, at "infinity" as far as the focusing action of the lenticule is concerned. This means that the apertures or filter bands, or images of them, can be at any distance greater than a few inches from the film, and still be focused on the emulsion by the lenticules.

Another effect, however, causes difficulty unless the apertures appear to be at infinity as seen from the lenticules. This is an angular effect, and is illustrated in Fig. 9. For convenience in reference, we shall assume that a filter is being used, but the discussion applies equally to a geometrical system employing unfiltered apertures. At the top of Fig. 9 is shown an optical diagram of a four-banded filter (or its image) placed 5 in. from the film. The lenticules on the film face the filter, but are far too small to be seen at the scale employed in the figure. Their long dimensions are perpendicular to the plane of the diagram. In the plane of the diagram, the outer edges of the two blue filter bands subtend an *f*/2.3 cone at the film, while the red and the green bands each subtend *f*/10 cones. The height of one 35mm camera frame extends from point *A* to point *C*. Point *B* is the intersection of the optical axis with the film, and lies midway between *A* and *C*. Light ray *1* is drawn from the intersection of the red and the green filter bands. Rays *2* and *3* are drawn from the outer edges of the two blue bands. At the top of the figure, these rays are shown converging on point *A* at the upper edge of the film frame.

Other diagrams could be drawn showing the convergence of similar rays at points *B* and *C* of the film. In the lower part of Fig. 9, there are shown greatly magnified views of such diagrams, taken at points *A*, *B* and *C*. The magnification amounts to approximately 400 times. In each case, rays *1*, *2* and *3* emanate from the same points of the filter, as shown at the top of the figure. Although at point *B* the filter bands will be imaged exactly within the confines of one lenticule, at points *A* and *C*, and at other points above or below the axis,

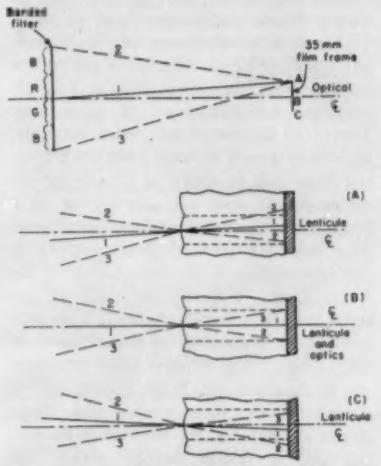

Fig. 9. Angular effect introduced by the height of the frame when the banded filter is at a finite optical distance from the film plane.

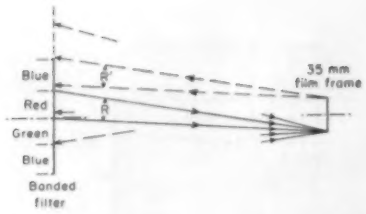

Fig. 10. Color errors which would occur in a continuous projector as a result of the angular effect illustrated in Fig. 9.

such will not be the case. At point *A* the filter images are shifted upward, and encroach somewhat upon the area behind the adjacent lenticule, while at *C* the images are shifted downward. At each of the points *A* and *C* the displacement amounts to about one-seventh the height of a lenticule, if the filters are effectively 5 in. from the film. This shift is of no consequence if the projection system exactly duplicates the angular relationships of the recording system, because then the paths of the light rays will be exactly the reverse of those shown in Fig. 9. With light traveling from right to left in the diagram, the photographic records of the filter bands will be imaged exactly upon the corresponding bands of the projection filter. However, if during projection the film frame is not registered in exactly the same position with respect to the optical axis as it occupied in recording, then color errors will appear in the reproduction, the severity of the errors depending upon the degree of misregistration.

In this discussion of angular effects, it has been assumed that the film is advanced intermittently and thus is stationary during exposure and projection. In television, however, the film may be in continuous motion during projection so that a flying-spot scanner can be used. The optical arrangement of Fig. 9, having the filter bands effectively only a few inches from the lenticules, is entirely unsuited to this type of projection. Figure 10 illustrates the point. Here the light rays drawn in solid lines are traveling from left to right, as shown by the arrow heads, and are converging on a lenticule at the bottom of the film frame. Five rays are shown, corresponding to the boundaries of the four bands of the filter. Cone *R* shows the path of the light from the "red" channel. This represents the recording of one element of the picture. The broken lines represent the paths along which the corresponding rays strike the filter during projection, if this element of the picture is located one-half a frame height above the optical axis when it is scanned in a continuous projector. Cone *R'* shows the path of the light transmitted during projection by the red-separation image. It is seen that part of this light will be lost by falling outside the projection filter, but most of it will be reproduced falsely as blue information. One of the bands of blue information will be reproduced mostly as green, the green will be reproduced mostly as red, and so on.

In Figs. 9 and 10, the virtual image of the banded filter has been placed only 5 in. distant from the lenticules in order to illustrate clearly the angular effects introduced by the finite height of the film frame and by motion of the film in a continuous projector. In practice, the distance of the virtual image of the banded filter from the film is determined by the position of the filter with respect to the camera or projector lens. This lens is between the actual filter and the film. It has been omitted from Figs. 9 and 10 to simplify the diagrams. The bands of the filter must, of course, always be proportioned so that their virtual images subtend the proper angles, as seen from the point of intersection of the optical axis and the film plane. The farther these images are from the film, however, the smaller are the angular effects of frame height and of film motion. Ideally, the distance from the film to the virtual image of the banded filter should be infinite.

This "infinity" condition is attained by placing the banded filter, or the unfiltered apertures of the geometrical separation system, at the front focal point of the objective lens in the camera, and at the corresponding focal point of the projection lens. As seen from the lenticules, the filter bands then will appear to be at infinity. The benefit of this arrangement can be seen in Fig. 11, which illustrates a camera fulfilling the infinity condition. The important point to notice is that the cones of light striking the film at points *A*, *B* and *C* are all parallel with each other and will record as at *B* in Fig. 9, just filling the emulsion area directly behind each lenticule. A film recorded in the camera of Fig. 11 would project properly on a continuous projector having a flat gate, provided that this projector also fulfilled the infinity condition. This can readily be seen by moving the film in Fig. 11 upward until point *C* coincides with the original point *A*, and then reversing the direction of the light rays.

Actually, however, continuous projectors generally have curved gates, and, whenever embossed film exposed under

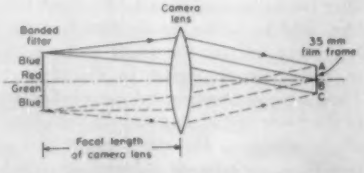

Fig. 11. Recording under the "infinity" condition.

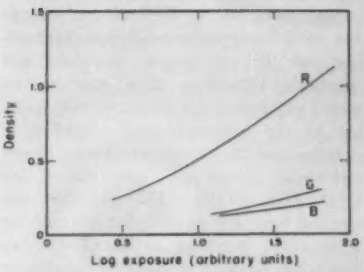

Fig. 12. Separation of color information achieved with an experimental embossed film.

the infinity condition on a flat gate is subsequently used in any apparatus having a curved film gate, an optical effect introduced by curvature of the film must be taken into account. For example, at the time it is being scanned in a continuous projector, the film may have its emulsion side in contact with a convex cylindrical gate. In this case, the rays passing along the optical axes of the individual lenticules will diverge from a common point, the center of curvature of the gate. The optics of the pickup system must then be designed to bring these rays to a focus upon the optical axis of the projector, at its intersection with the plane of separation. This amounts to imaging the center of curvature of the film gate at that point.

Recording under the infinity condition places the unusual requirement upon the camera objective lens, that its aperture stop should be at the front focal point. If the effective aperture stop of the lens is located elsewhere, there will be parallax between the recording apertures and the actual lens aperture, as seen from the film. This means that the recording apertures will be vignetted in varying amounts as seen from different parts of the film frame. The result will be a color shading, or wedging, in the picture. Such shading can be minimized by using a symmetrical five-band filter in place of the four-band filter, but for kinescope recording and play-back, this introduces a considerable complication of apparatus and does not offer a complete cure anyway. Consequently, at the Eastman Kodak Co. a special camera lens is being designed, which will make the recording apertures placed at its front focal point be the effective apertures of the system, over the entire field.

Film Emulsion Characteristics

The emulsion used on embossed film for kinescope recording must, of course, have adequate speed, and a transfer characteristic which can be accommodated by the rest of the system. In addition, it must be capable of recording separately the four bands of light imaged behind each lenticule. There are 100 of these bands per millimeter.

If, for example, an exposure is made hrough the recording aperture of the red channel, this exposure should not produce density in the immediately adjacent areas of the film which are reserved for the green- and the blue-channel records. Intermixing of the information in the four bands behind each lenticule will, in the general case, lead to an incorrect reproduction of color. In practice, there is a certain amount of such intermixing, even when the geometrical separation method of recording is employed. With such a system, the light from the three different channels is well separated when it first encounters the emulsion layer of the film, but it is then subject to scattering by the silver halide grains of the emulsion. The light scattered outside the optical image of each band exposes an emulsion area which is utilized by one of the adjacent bands, and thus causes intermixing of the color information. This situation can be alleviated by symmetrically reducing the height of each aperture opening by approximately 10%. As seen from the lenticules, the four recording apertures are then separated by narrow dark lines or "guard bands." Similar guard bands may be employed in the projector. It is well known that photographic images obtained by exposure to ultraviolet radiation are more confined to the surface of the emulsion than are similar images obtained by exposure to light of longer wavelength, because the emulsion is more opaque to ultraviolet radiation. Similarly, intermixing of color information in embossed film can be minimized by using a kinescope phosphor such as P-16, which has its peak emission in the near-ultraviolet region.

Even with these precautions, however, ordinary emulsions leave something to be desired. An experimental emulsion, especially designed for kinescope recording with the P-16 phosphor, is now under test, both at the Kodak Research Laboratories and in the trade. The *D*-log *E* curves shown in Fig. 12 illustrate the degree of color separation which is attained with this film. Guard bands were employed, and exposure was made by means of an RCA 5ZP-16 Kinescope. A step tablet was placed over the unmodulated kinescope raster, and the recording camera was focused upon the tablet. Exposure was made through the red-channel aperture only. After development, the film densities were determined on a Westrex Densitometer, Model RA 1100-B, which had been modified to read separately the densities recorded in the various positions behind the lenticules. Curve R shows the densities obtained in the "red" position behind the lenticules; Curve G shows the densities recorded in the "green" position; and curve B shows those in the "blue" position. The densities recorded in the green and in the blue bands by exposure of the red band are very low. On an exposure basis, the separation is better than 1.0 in log units.

Conclusion

The embossed-film method of color kinescope recording has many advantages. Like the color-television system, it employs additive principles, and therefore does not introduce new color problems. In comparison with other additive processes, the embossed-film method possesses the unique advantage that, after the recording step, the three color-separations are automatically maintained in register. This is not influenced by film shrinkage. An exacting color-registration problem exists in the three-channel recorder, but this is also encountered with other systems. With embossed film, the registration problem can be avoided in the subsequent steps of televising and of printing, with consequent simplification of the optical systems. The time required to develop the film is short, and the processing procedure is simple, thus meeting the requirements of time-zone-delayed broadcasting. Rapid handling of the film is also facilitated by the fact that relatively bright safelights can be used.

Although attention has been focused upon the problem of color kinescope recording, it will be realized that embossed film has other potential uses in conjunction with the color-television system. Experience gained in the commercial development of the color kinescope recording method will aid future evaluation of these possibilities.

Acknowledgment

It is a pleasure to acknowledge the substantial contributions to this work which have been made not only by our colleagues in the Research Laboratories, Eastman Kodak Co., but also by members of the Apparatus and Optical Div., Eastman Kodak Co.

Discussion

William L. Hughes (*Iowa State College*): I would like to make one statement: It is true that the systems we're discussing are somewhat competitive yet it has been necessary for me to have tests run on film, tests that we were not equipped to make. These tests have been run for me by the laboratories of Eastman Kodak Co., free of charge.

J. A. Maurer (*Consultant*): This may become a rather involved question. I hope I can make myself clear without the aid of diagrams. To anyone with a reasonable knowledge of the optics involved in this thing, it becomes apparent pretty quickly that the structure of your lenticular film is dictated by refractive index and thickness of the film base. Therefore, you cannot arbitrarily change the number of lenticules in a picture height, but you have to work with what you have available. This, then, ramifies in three directions: first, how have you found the number of lenticules you can put in a 35mm film to be as to the adequacy of the picture detail that you can transmit through it. Second, if by any choice of film base or even by merely making an existing type of film base thinner, you could use more lenticules per inch, would the available photographic emulsions have adequate resolving power to do a proper job on the separation of the color bands. And third, if you were to go, let us say, to a film like 55mm film thereby getting more lenticules in the picture area, does that involve any film manufacturing or optical problems that you know of that would complicate the situation?

Mr. Evans: Despite the fact that we are working with a film of fixed thickness and index of refraction the number of lenticules per millimeter can be changed because the aperture of the lenticules can be varied, and the focal length will remain the same. You use the same radius of curvature on each surface but merely reduce the height of each lenticule. We have done some experiments, for instance, with films having 30 lines per millimeter. Twenty-five lines per mm was standard for the motion-picture film which we made prior to this application, and it seems to be adequate for the present purpose. As to the resolution of the film emulsion, if we did increase the number of lenticules, I don't think we could get very far without running into trouble—degradation of the color by overlap from one band to the next, and so on. As to the increased size of 55 mm film, I don't think there would be much problem in manufacturing such a film, but I'm not so sure about the associated optics—that might require something special.

John Voorhees (*White Sands Proving Ground*): Does the smallness of these lenticular ridges on the film cause serious mechanical problems as far as accuracy of registration in the projectors and cameras is concerned?

Mr. Evans: No, there is no color-registration problem at all. Each one of the lenticules sends the light where it should and, with a proper optical system, it doesn't matter if the lenticules are moved up or down in the gate. One of the problems that some of the motion-picture engineers here will remember is that if you get oil on the film it wipes the lenticules by filling them in, so careful handling is required. However, it has been found that this isn't too serious a problem.

Mauro Zambuto (*Transound Inc.*): Several years ago somebody in Italy was toying with a similar system. All my information about it is second hand, I had nothing to do with the experiments; but I was made aware of a number of practical problems, some of which you have already mentioned.

A first major problem was registration of the filter band in the focal plane of the lenticules. To focus properly in the camera they had to go through a series of actual photographic tests; no simpler and faster method seems to have given acceptable results.

Also, and particularly with larger frame sizes, the lenticular system is a nonparaxial one at the borders. This gave rise to a number of optical problems which became in turn mechanical. I know they tried to bend the film at the aperture.

Another bad problem was dirt and oil, and finally they experienced severe buckling problems. It seems that tolerances there are quite small and having to use a terrific amount of light in projection didn't help at all.

This problem of the amount of light needed in projection was incidentally the reason the experiment was discontinued for motion-picture use.

In this application, of course, you don't have this problem, but I'd like to know if you have experienced any of the other ones and how they were solved.

Mr. Evans: We entered the project with a vast amount of practical experience gained by various people in our organization who had been involved in applications of embossed film to motion pictures. The Eastman Kodak Co. had an amateur process on the market back in the 1920's and early 1930's, which depended upon the same type of film. In the printed paper you will find a discussion of the position of the filter with respect to the lens. There is a problem involved if you project the film from a curved gate after exposing it on a flat gate, and that also is discussed. We believe that all these problems can be met satisfactorily, and it is a question of equipment design to begin with. The user needn't be bothered by it.

(((*Discussion was interrupted here in the recording and some discussion was lost through a recording mishap. When an intelligible signal was again available, the Ampex Videotape Recorder was under discussion.*)))

Anon: How do you keep synchronization when there are no sprockets?

Mr. Snyder: This is done by recording on a control track along one edge of the tape a representation of the line frequency, a frequency which is directly proportional to the line frequency which fed the recorder at the time of the recording. This is used in an electronic servo system to put out a correction signal to the synchronous drive apparatus. It operates on much the same principle as at least three systems which synchronize ¼-in. magnetic tape with projectors or with cameras. There's one we no longer manufacture, there's one by Fairchild and one by Rangertone; it's very similar.

George Lewin (Army Pictorial Center): Could you tell us whether the texture of the oxide on the tape that you use is the same as commercially available or did you have to use specially prepared surfaces?

Mr. Snyder: We experimented with a very large number of small variations in oxides. The oxides which have been successful do differ somewhat from those used on ordinary ¼-in. tape.

Mr. Lewin: From the published information which appeared in the press we know that the speed of the tape is 15 inches a second and the rotational speed of the heads is 14,000 revolutions per minute — so that it becomes a matter of more or less simple geometry to estimate that the width that's available for each magnetic scanning line is only about 16 mils.

Mr. Snyder: I can't confirm that.

Mr. Lewin: That's the reason I thought you'd require an extraordinarily pure texture on the tape in order to get any freedom at all from the usual dropouts that bother magnetic sound recording.

Mr. Snyder: I believe it's safe for me to say that dropouts are no problem, thanks largely to the efforts of the tape manufacturers.

Mauro Zambuto (Transound, Inc.): What kind of bias are you using? Is this an a-c bias or d-c bias, and if this is an a-c bias can you give us any idea as to the frequency?

Mr. Snyder: This is the kind of question which will be answered in full this fall. I understand the reason for your request and I hope you understand my not being able to answer it.

Cecil S. Bidlack (NAEB): Does this synchronizing track eliminate the necessity for any framing device such as you have on a projector in order to keep your heads in sync with the track?

Mr. Snyder: Not totally. The framing device which is there is, however, fully automatic.

Mr. Bidlack: Is there a possibility of making copies of these tapes?

Mr. Snyder: It has been done and successfully.

Anon: You said that dropouts are not a problem; does this infer that they are not a problem in color either?

Mr. Snyder: To give an answer to that would be a prediction rather than a statement and I'm afraid of predictions—I've made so many wrong ones.

Mr. Hughes: I realize this is one question you may not want to answer but would you care to say what form the color recording you do will take? In other words do you plan to put the encoded NTSC signal on or do you plan to encode it in some other way?

Mr. Snyder: We plan to have the operation of the machine as a color recorder entirely compatible with it's operation as a monochrome recorder. We intend that you should feed the whole signal into the machine and that you should get its replica out of the machine.

Mr. Hughes: In other words a station with the tape would not need an encoder to transmit it?

Mr. Snyder: Presumably, that is safe to say.

Anon: Have you run any edited tapes on this machine?

Mr. Snyder: Yes.

Anon: Were you able to keep, shall we say the frame lines, correct?

Mr. Snyder: Yes.

Mr. Lewin: Because of the system we have developed at the Pictorial Center in synchronous sound recording whereby we can erase errors during the narration, back the tape and projector up and then make the correction without making any cuts in the tape, I wonder, just looking into the future, whether you visualize that this same thing can be done with the picture? That is after a certain portion of the scene has been completed, if you make a cut you could back up and then on cue turn on the video signal and proceed with the scene, erasing an NG portion that you had previously made, and thus eliminate the need for making splices in the film.

Mr. Snyder: That's one of those fascinating things we have yet to explore. Applications of this machine as a substitute for the 35mm motion-picture camera are so speculative that almost anything we say today is likely to be wrong tomorrow. Some techniques will be developed which we don't yet imagine. The machine was designed primarily to record an uninterrupted program as long as possible. Editing, cutting, fading and similar practices are matters for the future. We'll have more answers for you this fall, but I expect not even then to have full answers to all these questions. Beyond its application as a time delay device, to overcome the three-hour east-west difference, the Videotape Recorder's functions have yet to be explored.

J. A. Maurer: Mr. Chairman, I wonder if you will accept what is a comment rather than a question in relation to this. To one whose activity has been primarily in the photographic field, although not having completely ignored electronics, it is fascinating to see the urge which the electronic workers have to extend the frontiers of their art. I think it might well cause the workers in the photographic field to do some severe criticism of their own approaches to things. I'd like to throw out the comment for reactions from anyone else who might feel qualified to make a similar observation. From what I know of the electronic and magnetic recording field and what I know of the photographic field, less technical effort and less expansion of horizons would be involved in producing a satisfactory 8mm color kinescope image with high fidelity sound to do this kind of a job with something on the order of 30-second processing from dry film to dry film, than has gone into this work of perfecting electronic recording by dissecting the image into little bits and then learning how to put it together again. I wonder if the photographic field ought not to make a greater effort in extending its own horizons.

Mr. Snyder: I wish someone would ask me if we think that recording pictures on magnetic media would ever replace the photographic film, because my answer would be a resounding "No."

A Four-Track Magnetic Transducer With Replaceable Working Gaps

By R. A. BULL

Magnetic transducers for 4-track release prints have a limited life due to wear of the magnetic gaps, and, in the theater field, the economic aspect of continued replacement becomes significant. A transducer is described in which the working gaps and wearing surfaces are replaceable units.

THE ADOPTION of 4-track magnetic release prints did not appear at first to introduce any new basic requirements to the design of magnetic reproducer transducers. The fundamentals were well understood and the major problem to which attention was directed was associated with large-scale production within the necessary performance tolerances. However, the magnetic coating used for striping consists of a conglomerate of red iron oxide in a vinyl or similar base and is an abrasive material. Its abrasive characteristics are in fact not very dissimilar to the rouge used as a grinding and finishing material.

Practical magnetic iron for transducer gap construction, usually of the Permalloy group, is relatively soft in the annealed condition and does not have particularly good resistance to abrasion properties. Thus the working gap of a practical magnetic transducer is subject to wear and inevitably has a limited life.[1] In the theater field, a magnetic transducer may handle a million feet of film every week or so and if the life of the transducer is limited to the passage of 2 to 3 million feet, the economic aspect becomes significant. The cost of a transducer cluster is inevitably somewhat high, so to design a transducer in which the working gaps and wearing surfaces are replaceable is a worthwhile pursuit.

In the design of a traditional ring core magnetic transducer it is usual to employ two gaps, one at the front which is in contact with the recorded media, and one located diametrically opposite the front gap. The output of a reproducer transducer varies as

$$20 \log \frac{\sin \frac{\pi \cdot l}{\lambda}}{\frac{\pi \cdot l}{\lambda}}$$

where l = effective front gap length measured in the direction of the traverse of the media;
and λ = wave length recorded on the track.

The dimensions of the front gap are therefore dictated by the desired response characteristic and by the width of the track being scanned. At a film speed of 90 ft/min an effective gap length of 1 mil will produce a 5-db transmission loss at 10 kc; an 0.5 mil gap, 5-db loss at 20 kc; and an 0.25-mil gap, 5-db loss at 40 kc.

It is usual to form both front and back gaps with nonmagnetic spacers and for the front working gap to employ a material which is harder than the magnetic iron core material in order to avoid the front gap being bridged by magnetic particles removed from the record. The effective front working gap is in practice somewhat greater than the spacer thickness and depends in practice on a number of factors such as the quality of the shear produced by the lamination stamping tool and the accuracy of the assembly. With good laminations and with precision in assembly the effective gap may be anything from 1.2 to 1.5 times the spacer thickness.

The function of the back gap in a ring transducer is to reduce the effect of spurious d-c magnetization and thus to reduce the effect of damage to a recorded track by superimposing on it noise from the d-c magnetization. The larger this back-gap length the smaller becomes the remanent induction due to accidental exposure to a d-c field. However, as the back gap is made larger the reluctance of the gap increases and the efficiency of the transducer decreases. For example, if the front gap reluctance F is kept constant and the back gap reluctance B made variable, but the inductance maintained constant by adjustment of the winding, then for constant excitation from a recorded track, the transducer output will decrease by $10 \log \frac{F}{F+B}$ as the back gap reluctance B is increased.[2] Thus, whereas the choice of front-gap dimensions is dictated by frequency response considerations, the choice of back gap dimensions is a compromise between the avoidance of d-c induction effect and the maintenance of a practical efficiency.

Now the reluctance of an assembly of Permalloy stampings of toroidal form having dimensions suitable for a transducer for 4-track release prints, is of the order of 0.003 cm^{-1}. Similarly the reluctance of a front working gap utilizing an 0.5-mil spacer and having an effective gap factor of 1.3 and a scanning width of 63 mils and a depth of 10 mils is of the order of 0.3 cm^{-1}, while the reluctance of a back gap utilizing a 10-mil spacer with the same effective gap factor and width but a depth of 125 mils is about 0.6 cm^{-1}. Thus it will be seen that the total ring reluctance is in practice dominated by gap reluctances and it becomes practicable to consider the introduction of further effective gaps to fulfil the desire to make the working front gap a replaceable element.

Obviously the introduction of a replaceable element must involve the introduction of two further gaps and it was found that gaps formed by the butt joint of ground surfaces in a ring Permalloy structure had a reluctance equivalent to that of a 0.2- to 0.3-mil gap at each butt junction. Since these butt joints can be of appreciable area, their reluctance can be kept down to the order of a few times the core ring reluctance or about 0.006 to 0.01 cm^{-1}. The relationship usually taken as indicative of relative transducer efficiency is E^2/L where E is the output voltage of the transducer for a given excitation and L is the inductance. It can be shown that the ratio E^2/L is proportional to $F^2/(F + B)$ from which it may be inferred that the loss due to the additional reluctance of the butt joints of replaceable gap units would be a fraction of 1 db.

Figure 1 shows a 4-track head embodying the feature of replaceable working gaps, and Fig. 2 shows the essential design features. Wound lamination assemblies **a**, brass clamps **b**, brass spacers **c** and magnetic inter-shield **d**, are mounted together to form a subassembly. Two such subassemblies are then in turn mounted together on plate **l**, together with magnetic shields **f**, spacer **g** and endplate **h**. A reamed hole through the center of the assembly takes a central pillar which engages a seating in the baseplate **i** and the top screw **j**. Four adjusting screws **k** press against the baseplate. The replaceable gap assemblies **e** are inserted in slots in the subassemblies. The piece parts of these assemblies are made to commercial tolerances and the final assembly is brought to the required accuracy of positioning of the working gaps by means of shims.

If the film traversed the working gaps as a perfect cylindrical surface the bed-

A contribution submitted on April 12, 1956, by R. A. Bull, Westrex Co., Ltd., Liberty House, Regent St., London W1.

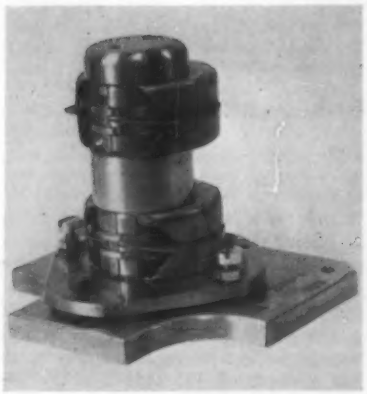

Fig. 1. Four-track transducer with replaceable working gaps.

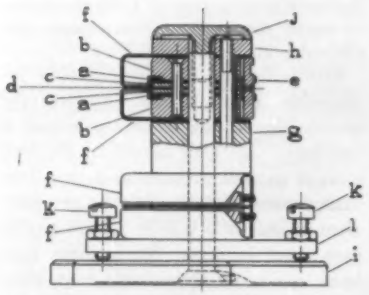

Fig. 2. Design features of 4-track transducer.

ding surfaces upon which the gap elements make magnetic contact would obviously be machined in one plane. However due to the longitudinal tension of the film, the transverse contour of the film is slightly hollow, with the result that the two inner gaps normally tend to wear at a more rapid rate than the outer gaps. It has been found that a better initial fit to the film contour, with more uniform wear, is obtained if the bedding surfaces are machined in the form of a very shallow V, which in fact differs from the flat plane by 0.6°.

The construction of the replaceable working gap element is shown in Fig. 3. The gaps are assembled in pairs. The pole pieces **a** each side of the working gap spacer **b,** are not laminated, and thus the film tracks on a homogeneous surface. The four pole piece elements, after their ends have been appropriately machined to make the gap, the two gap spacers and the supporting brass bar **c,** are silver brazed together in a jig by passing a heating current through the brass bar. The film contact surfaces are turned and ground on a multiple mandrel.

The pair of gaps which forms a replaceable unit is retained in situ by a single screw and it is practicable to assure an azimuth accuracy of ±5 minutes. Mechanical inspection of the accuracy of the butt surfaces between pole tip and ring is checked by the simple expedient of assembly with 0.5-mil spacers in the butt joints; a spacer not retained when the gap assembly is screwed home is indicative of a faulty part.

In making the choice of inductance to which a magnetic transducer is to be wound, consideration has to be given to the circuit into which the transducer will work and the frequency at which any resonance will occur due to the capacity of this input circuit. In order to maintain the high frequency response it was decided to place this resonance at 8.5 kc which is some 2 kc higher than is usual with transducers for 4-track magnetic film. This choice results in an inductance of 1.8 mh and in a transducer which has a lower open circuit voltage than is usual by 2.5 to 3 db up to 6 kc. The choice however is a rational compromise since at 12 kc the output is better by 4 to 5 db.

The efficiency of the head could have been increased if the back gap had been made smaller at the expense of an increased d-c induction effect. It was felt, however, that the maintenance of a low d-c induction effect was a highly desirable feature. In order to check the magnitude of this effect the head was exposed to a high d-c field and then used to record on virgin film by a rapid mechanical interruption of the intimate contact between the running film and the working gaps. When played back the noise level that had been recorded due to d-c induction was rather more than 40 db below the average recorded level of release prints.

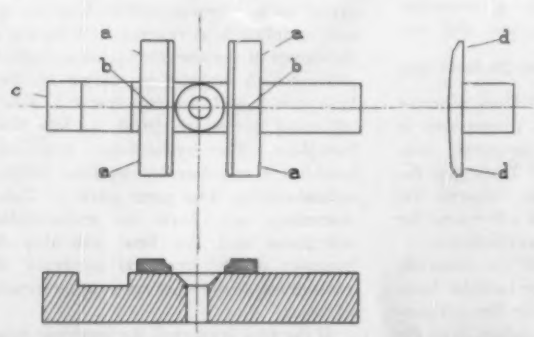

Fig. 3. Design features of replaceable working gap element.

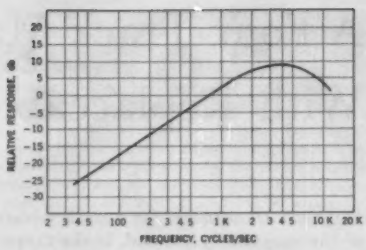

Fig. 4. Reproduced response from constant-current recording (including input-transformer and magnetic-stripe characteristics).

The transducer can be used equally for recording and reproducing. The overall response of the head with its input transformer, including the characteristics of the magnetic stripe, when constant current is supplied to the head and the record is reproduced on the same head, is shown on Fig. 4.

It is more than probable that the effective front gap reluctance of magnetic transducers is not a constant dependent solely on its geometry and dimensions, but is influenced by the frequency present on the recorded media. When the wave length on the recorded media is appreciably longer than the gap and comparable with the length of the wrap between film and transducer, the effective magnetic induction into the pole pieces can take place over an appreciable area.

When, however, the wave length is approaching the dimensions of the working gap, the effective induction may be confined to the tips of the pole pieces adjacent to the gap. These tips represent a discontinuity in the magnetic material and are subjected to abrasion from the film stripe which may reduce their permeability. The abrasion may also result in minute undercutting. The result is that as frequency increases the

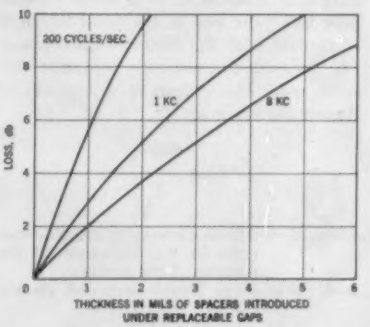

Fig. 5. Variation of efficiency with gaps deliberately introduced under replaceable units. This shows that the loss is not constant with frequency and suggests that the working gap reluctance increases with frequency.

effective reluctance of the working gap tends to increase. The effect of this is shown in Fig. 5, which is a family of curves relating loss in efficiency with the length of an air gap deliberately introduced by nonmagnetic spacers fitted under the replaceable gap units. It will be seen that the slope of the loss curves becomes less with increase in frequency, which is in accord with a reluctance in the magnetic circuit which is increasing with frequency.

A wide experience with transducers with replaceable working gap elements has shown the design to be eminently practicable. The replacement of the gaps requires no special skill, occupies a few minutes and the only tool required is a screwdriver. The life of the gaps varies appreciably dependent on whether they are exposed to new or old film but a typical life is between $2\frac{1}{2}$ and $3\frac{1}{2}$ million feet. The economic value of the design is emphasized by the fact that a set of two replaceable gap units costs under 9% of the cost of the transducer cluster complete.

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Professional Printing Techniques for Ansco Color Negative-Positive Motion Picture Film

By KARL SCHADLICH

Printing from Ansco color negative onto Ansco positive is relatively simple, but it does require certain changes in technique, equipment and timing. These requirements are described. The technique of timing for color printing with color correction filters is described with particular attention to some of the reasons why anticipated results are not always attained.

THE TRANSITION from black-and-white to color printing has brought about new problems. New printing techniques must be developed and new skills acquired in order to turn out quality prints. These problems are encountered with all kinds of color film. They are of general interest and a number of the more important ones as they apply to current motion-picture color products will be reviewed.

The Ansco Color Negative-Positive Process has been described in the *Journal*.[1] The process is conventional and follows the flow chart as shown in Fig. 1. Release prints are made from Type 844 original negatives or from Type 846 duplicate negatives.

Presented on October 5, 1955, at the Society's Convention at Lake Placid, N.Y., by Karl Schadlich, Ansco, Binghamton, N.Y.
(This paper was received on April 25, 1956.)

The original photography is done on Type 844 camera negative film. To provide for protection and/or special effects, a set of separation positives can be made from the original negative, and a duplicate negative in turn, is made from the separations on Type 846 duplicating negative film. Usually a printing master is composed of intercut Type 844 and Type 846 negative films.

Both negative types contain the same image dyes so that there can be no difference in effective printing density. The print stock is Ansco Color Positive Type 848. It is balanced to be used for prints from complementary color negatives such as Types 844 and 846. Figure 2 shows the sensitometric characteristics of Type 848 which, with normal processing,

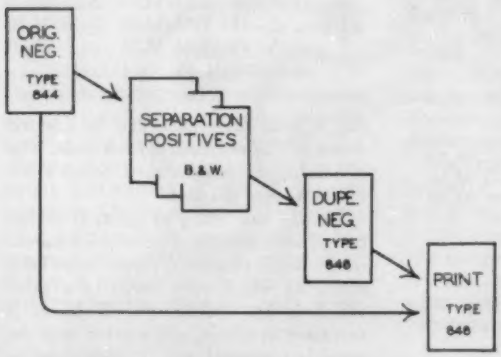

Fig. 1. Ansco Color Negative-Positive Process.

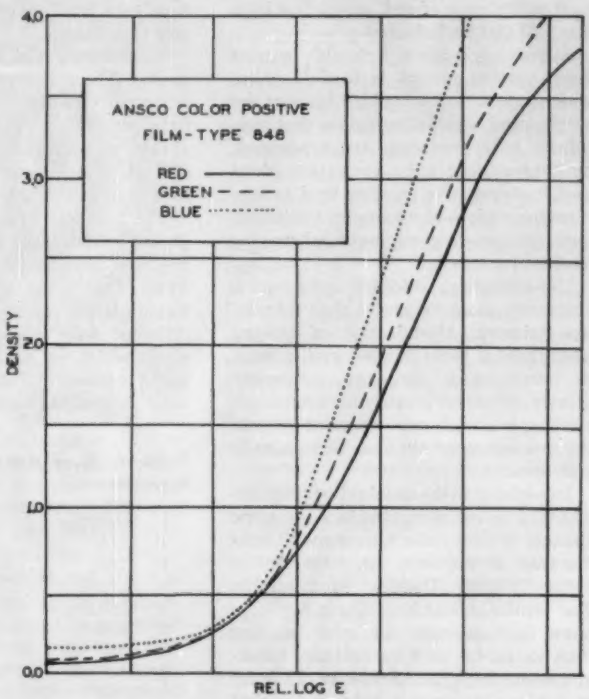

Fig. 2. Sensitometric characteristics of Ansco Color Positive Film Type 848.

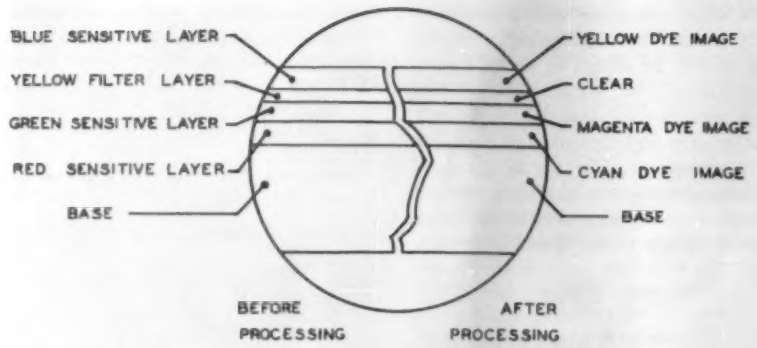

Fig. 3. Layer arrangement of Ansco Color-Type 848 Positive Film.

has red gamma 2.4, green gamma 2.5, and blue gamma 3.2.

The layer arrangement of Type 848 is shown in Fig. 3. The layer sensitivities are indicated on the left, and the resultant subtractive system dyes are indicated on the right.

Either additive or subtractive printing may be used. Additive printing consists of an exposure through each of three narrow-band red, green and blue filters. In effect, each layer of the color film is exposed individually and the intensity of each exposure is controlled so that the proper amount of each dye is formed to produced a balanced print. The three color exposures can be consecutive or simultaneous depending upon the printer.

Subtractive printing consists of a single white light exposure, but the white light is modulated with color correction filters to give the ratio of red, green and blue that will yield a balanced print.

Additive printing is preferable because more precise control is feasible. Also, some degradation is avoided because the overlapping sensitivity regions that contribute to degradation are suppressed. By contrast, the color correction filters used in subtractive printing tend to suppress the regions of maximum sensitivity, thus accentuating exposure where the sensitivities overlap.

Unfortunately, additive printing is ordinarily more expensive than subtractive printing. Modification of existing equipment is more difficult and is likely to result in a high-cost, slow-speed printer. Modified printers for subtractive printing are much more common because they are less expensive and easier to build and operate.

In addition to the usual printer requirements, a means of making scene-to-scene changes of both color filtration and light intensity is required to print Ansco-Color Negative-Positive subtractively. The printer should have about two stops more light intensity for color printing than would be used for ordinary black-and-white fine-grained positive. In order to balance the printer light, the optical system and the emulsion to each other, a basic filter pack is required. To protect these filters, we prefer a heat-reflecting glass such as the Calflex* rather than a heat absorbing glass, although either can be used successfully. A relatively large lamp operated at low voltage is preferable for stability. We use a 750-w lamp at 85 v. With an efficient optical system, there is enough light to print at 90 ft/min.

Many modifications of existing printers have been made and used successfully. We have used the Frank Herrnfeld Engineering Corp. modification of the Bell & Howell, Models D and J, printers with good success.[2] Other modifications are probably equally good, and the choice depends mainly upon personal preference.

The most difficult part of color printing is timing. Good timing is an art brought to its highest accomplishment by experience. Consistently good results will come from keen interpretation, good judgment and experience.

Sensitometry is of limited assistance in timing. The major value of sensitometry is to predict the differences when changing from one emulsion to another. This is not always an unqualified aid because it is difficult to anticipate precise pictorial results from sensitometry alone.

The best way to select the proper exposure is from scene tests made from the negative. Scene testers may be of many forms. One scene tester exposes a 16-frame platten containing a range of 16 different color correction filters.[2] The range which we have found to be most useful is shown in Table I. Large or small color increments may be used. Small increments require less interpolation, but do not cover as large a range and there is less latitude in the selection of the basic filter pack for gross correction. Conversely larger increments provide a greater range the basic filter pack is less critical, but the results require more interpolation. Usually, three or more platten exposures are made from each negative at different intensity levels to provide a density range. From these processed scene test strips, a satisfactory exposure and balance can be selected. Obviously, if the density and color increments are large enough to provide a practical range, then some interpolation is usually necessary.

Table I. Filter Range for Use on the Scene Tester.

1 – No Filter	9 – Y.15/M.15
2 – C.15	10 – Y.30/M.30
3 – C.30	11 – Y.40/M.20
4 – C.15/M.15	12 – Y.40
5 – C.30/M.30	13 – Y.25
6 – M.40	14 – Y.10
7 – M.25	15 – Y.15/C.15
8 – M.10	16 – Y.30/C.30

* Calflex filters are available from Photovolt Corp., 95 Madison Ave., New York, N.Y.

A suitable scene tester should be optically as much like the printer as possible so that the exposure will match the printer or at least provide a reasonable working correlation. This means that the lamps, exposure time, heat reflecting filters, and collimating lenses should match. The optical paths should also match or at least be similar. Mechanically, the scene tester should be designed so that the negative can be handled, wound to the scenes selected for testing and framed with the platten, without damage. A means of winding and advancing the raw stock for each exposure is also required.

Frequent cross-check tests should be made between the scene tester and the printers using representative negatives so that the correlation will be maintained. After the timer has attained some experience, he will not usually find it necessary to test each individual scene. An experienced timer can often group the scenes, select representative ones for testing, and select a suitable printing balance for each scene by judging minor differences.

In actual practice, the timer lists each scene with the total filtration and printer light selected for each scene. Table II shows a simple example. From this list, a basic filter pack can be selected which will be common to each scene. The remaining differences then become the scene-to-scene changes.

Table II. Selection of Basic Filter Pack.

Scene No.	Printer Light	Total Filtration	Scene-to-Scene Change
1	Light 10	Y.25/M.20	Y.10/M.05
2	" 12	Y.30/M.40	Y.15/M.25
3	" 9	Y.15/M.15	No filter
4	" 11	Y.30/M.25	Y.15/M.10
5	" 10	Y.35/M.15	Y.20
Basic Filter Pack		Y.15/m.15	

We are now ready to print. If all has been done correctly, a good print should result. But, a number of factors have been operating which may result in a print which is not satisfactory. If so, it is necessary to retime, and reprint until the error is corrected and a good print is obtained.

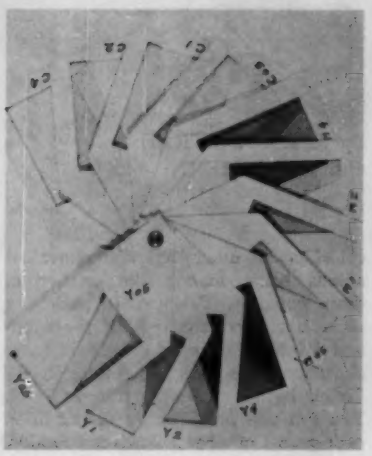

Fig. 4. Pieces of three subtractive filters mounted into card holders.

Unsatisfactory prints may be caused by poor correlation between scene tester and printer, change in processing, misjudgment in interpolation of scene tests, poor correlation between projector and viewer or poor judgment in favoring the balance of individual scenes.

It is important to match the color temperature of viewing tables and editing machines to the projector. This can be done by using daylight lamps and/or conversion filters. The blue plastic sheeting of the type used in flashlamp shields is inexpensive and effective for conversion. The Corning Glass No. 590 is also very satisfactory, but is more expensive.

We have found that the simple device shown in Fig. 4 is quite helpful in timing. It consists of pieces of the three subtractive filters mounted into card holders so that that they can be conveniently used. The scene tests or prints from which the timing is being done, can be viewed through various filter combinations in order to get some idea of the degree of color correction desired. This is limited because a color density filter contributes equal density throughout the scale. Actually, this does not occur in a print because then the shift is along the Log E axis, but by viewing, the shift is along the density axis. This means, that in printing for any given density change at the midrange, there is less change in the toe and no change at fog level. It takes a little experience to allow for this limitation.

After the desired amount of correction has been decided upon, the filter that will produce this result can be selected. The effective gamma of the print film is related to this selection (Fig. 5). If the print gamma is 2.0, the density change in the print will be twice the change in exposure. For example, if 0.10 more yellow density is required in the reprint, then 0.05 less yellow filtration should be used. Ansco color positive has a mean gamma of well over 2.0, but we find that for this purpose, it should be considered as 2.00. This is due to the differences between ordinary density measurements and effective printing density.

Occasionally, it will be helpful to compare an unknown negative with a negative whose printing conditions are known in order to find the proper exposure. The viewing filters can be used to advantage in this case. Sometimes large enough areas of flesh tone, or grey color are available to make density measurements.

These measurements or the viewing filters, will give some indication of the difference in filtration and exposure. Because density differences in the negatives are effective along the Log E axis, the gamma factor of the print is not concerned in this use of the viewing filters, and the actual value is used.

It is important to remember that we are concerned with three kinds of density in printing.[3] These are densities measured by the usual color densitometer, effective printing density and visual density. The densitometer will give the highest values. For Ansco color negative-positive, the effective printing densities relative to the MacBeth Color Densitometer[4] readings are red, 85%; green, 82%; and blue 77%. These values are approximate and will vary somewhat depending primarily upon the correction filters used. The visual densities by projection will also vary depending upon projection or viewing conditions, but will be somewhat lower than effective printing densities. Because of this, an estimated allowance should be made when using densitometer measurements for calculating printing differences.

A change in filtration will affect not only the color, but also the density of the print. Estimating this density change is the particular problem that many people find most difficult. The exposure allowance relative to the filter's color density, should be about 50% for cyan filters, 40% for magneta filters, and 25% for yellow filters. For example, a C-10 cyan filter will affect the overall density of a print about 0.05 or about 1 B & H printer step. This is a rule which attempts to account for both the neutral density value of the filter, and the apparent density change due to a change of one layer. Actually, the problem is too complex to formulate any simple rule. However, this guide is accurate enough to give good results when used judiciously.

The number of filter combinations needed in practice runs into hundreds. It is impractical to provide such a variety in single foils, so combinations are used. The make-up of combinations can result in filters of equivalent correction, but differing in the number of foils. Obviously

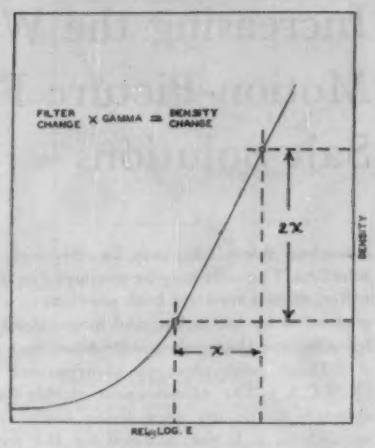

Fig. 5. Effect of gamma upon filter changes.

they will not have equal neutral density value. The least number of foils possible should be used. Ansco supplies a sufficient variety of foils so that the more common correction combinations are available as single foils, and it is very rare that more than two foils are required.

Consideration of these problems might lead one to believe that the commercial practicability of color printing is questionable. Certainly, the timing problem is difficult, and it would be unrealistic to minimize it.

Fortunately, one important factor works to the timer's advantage. Under projection conditions, the eye will accept a rather wide range of balances. This range is somewhat greater than the range that will be accepted when viewing reflection prints under ordinary viewing conditions in illuminated surroundings. The eye is a remarkably good comparison photometric instrument, but very poor at absolute measurements. The eye will overlook small errors in timing, but will not tolerate abrupt changes in balance from scene to scene, especially when the subject material provides a comparison reference.

The major problems may be overcome by skill, training and judgment. After some experience is gained, problems which seem difficult at first, become just a simple part of the day's routine.

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Increasing the Washing Rate of Motion-Picture Films With Salt Solutions

By J. I. CRABTREE
and R. W. HENN

Adsorbed thiosulfates may be effectively eliminated from films by the use of salt solutions. The salts may be employed in the wash water, as when washing with sea water, or as a separate bath previous to washing. The rate of elimination is largely controlled by the anion, and monovalent anions such as acetate and chloride are less effective than polyvalent anions such as sulfate, sulfite, phosphate and citrate.

These principles are incorporated in the Kodak Hypo Clearing Agent (K.H.C.A.). The effectiveness of this bath is most striking with films fixed in strongly hardening alum fixing baths and washed in cold water. Under these conditions, it is not unusual for the hypo to be reduced to 1% of that left by washing alone for equal periods. The results obtained when this product is applied to machine, spray, and rewind processing of motion-picture films, microfilms and aerial films are described. In general, savings are effected in both the time required and the water consumed, while very low levels of residual hypo are attained.

FIXING and washing combine to form the vital function of producing a photographic image whose permanency can be depended upon over a period of years. Crabtree, Eaton and Muehler investigated the stages of fixing and washing, and published a series of papers in this *Journal* about fifteen years ago.[1,2,3] They showed that the rate of washout of hypo and silver salts is dependent upon the composition of the fixer and upon its degree of use, washout rates decreasing with the very factors that make for good hardening, namely, the presence of alum, low pH and long fixing times. Washing also depended on the rate of flow of the water, on its turbulence, and on its temperature. They established tentative hypo tolerances and reviewed methods of measurement.

In one of the final papers of this series, they studied the effect of washing film with sea water,[4] which removed hypo much more rapidly than fresh water, and in some unpublished work they found an effect for sodium chloride and sodium sulfate baths used previous to washing.

The effects of salts in promoting washing was observed prior to the work of Eaton and Crabtree. However, since these observations were undocumented by quantitative measurements, the use of salts does not appear to have had any extensive practical application. Thus, in 1899, Bannow[5] found that the washing time of plates was cut in half or less by the use of a 10% solution of sodium chloride, and Baysellance[6] advocated the use of sea water or a 3% solution of sodium chloride for the washing of prints, followed by a fresh-water rinse.

It is the aim of this paper to provide an extension of this interrupted work with salt solutions, to examine a number of the factors affecting their use, to call attention to the large gains that are possible, and to make specific application to motion-picture processing.

Communication No. 1790 from the Kodak Research Laboratories, by J. I. Crabtree and R. W. Henn, Research Laboratories, Eastman Kodak Co., Rochester 4, N.Y. Presented on April 30, 1956, at the Society's Convention at New York by J. I. Crabtree.
(This paper was received on May 15, 1956.)

Table I. Nature of the Salt (Kodak Super-XX Sheet Film Bathed 2 Min; Washed 5 Min).

Bath	Residual hypo: Micrograms/sq in.	Residual hypo: Milligrams/sq in.
Water	340	0.340
2% Sodium chloride	160	0.160
2% Sodium nitrate	200	0.200
2% Sodium sulfate	105	0.105
2% Potassium sulfate	96	0.096
2% Ammonium sulfate	100	0.100
2% Magnesium sulfate	84	0.084
2% Sodium sulfite	8	0.008
2% Sodium bicarbonate*	10	0.010
2% Sodium phosphate, dibasic*	9	0.009
2% Sodium citrate	11	0.011
2% Sodium pyrophosphate, dibasic*	96	0.096

*pH adjusted to 7.5.

Examination of the Salt Effect

1. The Nature of the Salt

In the literature just quoted, sodium chloride was employed as the principal salt, together with whatever impurities might be present in sea water. However, many other salts are also effective, sodium chloride and other salts of monovalent anions being among the weaker of those noted in Table I. In gathering these data, Kodak Super-XX sheet film was developed, stopped in an acid bath, and fixed in an alum fixing bath, Kodak Fixing Bath F-5, for 10 min at 68 F. The F-5 was modified by the addition of 2 grams of silver, as silver bromide, per liter to simulate partial exhaustion. The film was then washed at 50 F with good circulation. Hypo was analyzed with the mercuric chloride test,[7] and residual hypo values were expressed in micrograms of anhydrous hypo per square inch.

A further examination of this table discloses that the several sulfates examined — sodium, potassium, ammonium and magnesium — were all about equally effective in removing hypo, lowering its content to one-third the value left by unaided washing. The pyrophosphate also had about this order of effectiveness, but the sulfite, carbonate, citrate and orthophosphate were much more effective, reducing the hypo content to around 10 micrograms/sq in.

However, the effectiveness of some of these salts is associated with the removal of alum hardening. This is indicated in Table II, where the hardening action is measured by fixing an unhardened film — Kodak Matrix — in the F-5 bath, then bathing for 5 min in the

Table II. Effect on Hardness (Kodak Matrix Film Fixed in Kodak F-5).

Solution	Net swelling* (In. × 10,000)	Net hardening* (°F)
Water	62	104
2% Sodium sulfite	72	102
2% Sodium sulfate	84	91
2% Sodium bicarbonate	109	67
2% Kodalk	128	27
2% Ammonium hydroxide (with sodium sulfate)	134	12
2% Sodium citrate	154	5
2% Sodium carbonate	156	3
Water†	118	2

*Compared with unprocessed film.
†Fixed in the nonhardening Kodak Fixing Bath F-24.

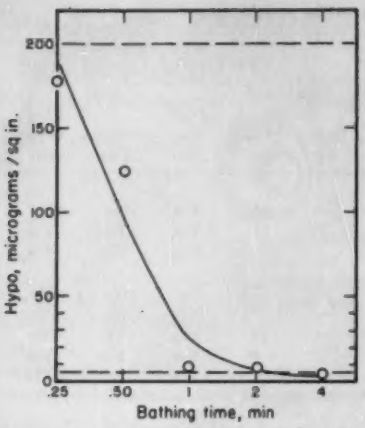

Fig. 1. Effect of time of bathing in a 2% solution of sodium sulfite. Kodak Super-XX sheet film was developed, fixed in F-5, bathed for the indicated times, and washed for 5 min.

several salt solutions, washing at 75 F, and (a) measuring the swelling with a thickness gauge and (b) measuring the melting point in the conventional manner.[8] The results are expressed as the net differences between unhardened film and the film receiving the several treatments. It will be seen that all the alkalies, and sodium citrate, removed the alum hardening, while the sodium sulfate and sodium sulfite had very little effect on hardening.

2. Effect of Time and Concentration

The effectiveness of the salt increases with (a) the time of washing and (b) the time of bathing. Thus, Fig. 1 shows that large effects were obtained by bathing the film for one or more minutes in a 2% solution of sodium sulfite and washing for 5 min, while Fig. 2 shows that bathing for 2 min in the sulfite solution, followed by only 1 min of washing, reduced the hypo content more than washing for one hour. Under some conditions, particularly with high agitation and thin emulsions, these times can be reduced to fractions of a minute, as illustrated later for motion-picture spray processing.

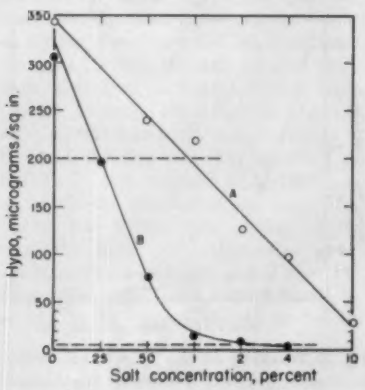

Fig. 3. Effect of concentration of the salt on removal of hypo. Kodak Super-XX sheet film was bathed for 2 min in solutions of (A) sodium sulfate, and (B) sodium sulfite, and then washed 10 min.

The effect of the salt solution increases with its concentration, as indicated in Fig. 3, in which the salts are sodium sulfite and sodium sulfate. A 1% solution of sodium sulfite or a 10% solution of sodium sulfate proved almost completely effective in eliminating hypo under these conditions of use, namely 2-min bathing, followed by 5-min washing.

3. Image Stability

Strips of fine-grain films and of prints, which were treated in a sodium sulfate solution, washed and incubated have proved to have the same stability as films or prints washed to equal hypo content without a salt bath. When the salt employed was sodium sulfite, the treated images actually showed better stability than would be anticipated from their hypo content, presumably owing to some stabilizing action of the sulfite on the thiosulfate, just as sulfite is added to fixing baths to prevent the hypo from sulfurizing. Also, incubation tests have indicated that films bathed in a salt solution before washing have less tendency toward highlight staining. This is associated with the removal of residual silver, as indicated in Fig. 4.

4. Theory of Action

The mechanism by which salts remove hypo differs from that of alkalies and oxidizing agents. Thus alkalies remove the alum which otherwise mordants the hypo, and treated films will be found to have reduced hardening, but this is not true for salts (Table II). Peroxides and other oxidizing agents chemically change the thiosulfate and are likely to leave the residual silver ion unaffected, but salts are effective in removing both hypo and silver. (This is most clearly seen with data on paper prints.[8a])

Crabtree and Eaton,[4] following a lead of Sheppard,[9] ascribed the accelerating action of sea water to an osmosis effect through a gelatin membrane. Alternately, much of the effect can be explained simply by ion displacement, akin to that occurring on exchange resins. The small number of thiosulfate ions adsorbed to the gelatin are displaced by the large number of sulfate or sulfite ions of the solution. The particular effectiveness of sodium sulfite may be connected with its close chemical relationship to thiosulfate, making the formation of double compounds possible and labilizing the sulfur atom, should this be present resulting from dissociation of the thiosulfate.

Practical Applications to Motion-Picture Films

The preceding section has shown that salts are highly effective in accelerating

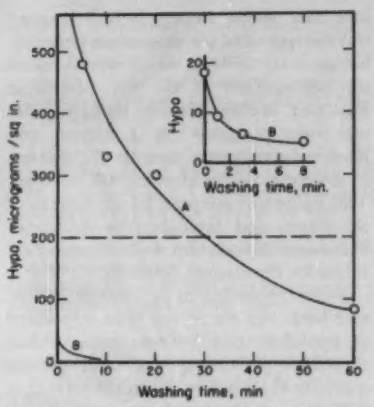

Fig. 2. Effect of time of washing. Curve A applies to the unaided washing of the Super-XX sheet film; curve B applies to washing after bathing for 2 min in a 2% sodium sulfite solution. This latter curve is enlarged in the insert figure.

the washing of hypo from films and that extremely low levels of residual hypo can be obtained in short washing times. In examining applications of this type of washing accelerator, the Kodak Hypo Clearing Agent (K.H.C.A.), a proprietary product based on the results of this investigation, was employed.

The conditions selected for its use are not necessarily optimum for a given situation, and variations of soaking time, washing time, rate of flow, hypo carry-over, acceptable hypo level, agitation and economy (degree of exhaustion) are, of course, possible. The hypo levels have been determined with the mercuric chloride test and have been checked with the silver nitrate test.[10]

1. Permissible Hypo Contents

The effect of traces of residual hypo in causing fading or change in hue of black-and-white images on motion-pic-

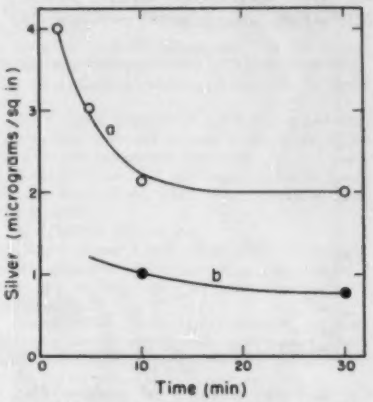

Fig. 4. Removal of residual silver. Kodak Verichrome Pan Film was (a) washed only, and (b) bathed in a 10% solution of sodium sulfate for 2 min, and then washed. Although expressed as metallic silver, the silver is actually present as a thiosulfate complex.

ture film during storage is well known,[1] but the extent of the maximum permissible quantity of hypo which would insure the permanency of the then available Eastman Motion-Picture Positive Film was first proposed by Crabtree and Ross,[7] who suggested a value of 0.005 mg (5 micrograms)/sq in. of crystalline hypo. This value was adopted by the Bureau of Standards and later by the American Standards Association as a standard for Films for Permanent Records.[11]

More recently, in a revised A.S.A. standard, this value has been stipulated as applying to anhydrous hypo which, therefore, permits a somewhat greater quantity than before. With the advent of still finer grain emulsions on motion-picture positive film, it may be necessary to lower this value to 3 micrograms/sq in. or less, which approaches the limit of accuracy of the mercuric chloride test.

The significance of these low values of residual hypo, therefore, tends to stress the importance of improved means for removing hypo from films during processing.

2. Machine Tests With Black-and-White Motion-Picture Films

Two machines at Kodak Park employ the K.H.C.A. product routinely in the processing of 35mm films, and some data gathered by a co-worker, G. McWilliams, are entered in Table III. The No. 1 machine previously employed thirteen 50-gal wash tanks, and, by the use of this extensive battery, succeeded in satisfactorily washing motion-picture positive film, although some difficulty was encountered with Kodak Micro-File and negative films.

When the K.H.C.A. salt bath was installed in two of the wash tanks, the speed of processing was doubled (from 50 to 105 ft/min), and the rate of water flow was cut in half simultaneously, yet the hypo level of all films — positive, Micro-File, and negative — stayed below 5 micrograms/sq in. This machine uses roller squeegees between tanks, and the rate of carry-over is low, so that high capacity is possible before changing the baths. Normally, about 250,000 ft of film are processed through the two 50-gal tanks of K.H.C.A., with one replenishment (equivalent to adding 25 gallons of fresh material to each tank).

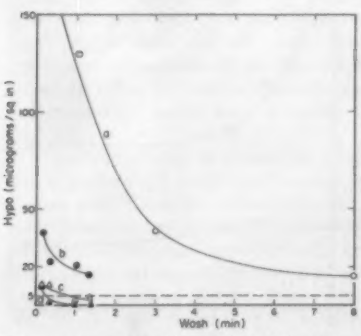

Fig. 5. Spray-washing of positive film. Eastman Fine Grain Positive Motion-Picture Film was (a) spray-washed without use of a salt solution, while the remaining curves are for film rinsed, bathed in K.H.C.A. for times of 10 sec (curve b), 20 sec (curve c), and 40 sec (curve d), and then washed.

Table III. Machine Processing of 35Mm Micro-File and Motion-Picture Films.[1]

Procedure	Film rate, ft/min	Water flow, gpm	Total time (min) Bathing	Total time (min) Washing	Acceptable hypo level (5 Micrograms/sq in. or less) Positive film	Micro-File	M.-P. negative
Machine No. 1, 13 Wash Tanks							
Wash only	50	10	—	26	Yes	No	No
Wash, K.H.C.A., Wash	105	5	2	11	Yes	Yes	Yes
Wash, K.H.C.A., Wash[3]					Yes	Yes	Yes
Machine No. 2, 3 Wash Tanks							
Wash only	20	8	—	7½	No	No	No
Ammonia to wash water	40	8	—	7½	Yes	No	No
Ammonia to wash water	20[3]	8	—	15	Yes	Yes	No
Wash, K.H.C.A., Wash	50	4	2	4	Yes	Yes	Yes
Wash, K.H.C.A., Wash[4]					Yes	Yes	Yes

Notes: (1) *Films Employed:*
5230—Eastman Background X Panchromatic Negative Film
5231—Eastman Plus-X Panchromatic Negative Film
5232—Eastman Super-XX Panchromatic Negative Film
5210—Eastman Infrared Negative Film
5203—Eastman Fine Grain Duplicating Panchromatic Negative Film
5365—Eastman Fine Grain Duplicating Positive Film
5241—Kodak Plus-X Film
5244—Kodak Linagraph Pan Film, Type X
5201—Kodak Micro-File Film
(2) After processing 246,000 ft in two 50-gal tanks.
(3) Requires slowing machine between developing and washing.
(4) After processing 93,000 to 100,000 ft/50 gal.

The second machine uses only three wash tanks. In order to obtain satisfactory washing, it has been necessary for some years to accelerate washing by dripping ammonia into the wash water. However, even with this expedient, it was necessary to interrupt the cycle after development and slow down the machine to provide adequate washing of microfilms. The use of K.H.C.A. completely overcame these difficulties. Installed in the central tank, it effectively washed all types of film to archival levels of hypo, with the machine operated at the highest rate of film travel and with half the normal flow of water. The capacity here was about 100,000 ft/50 gal.

The K.H.C.A. washing aid has also been successfully employed in commercial microfilming with a Houston machine. Placed in the center one of three 5-gal tanks, it reduced the hypo level from 22 to 1 microgram/sq in. and showed a capacity of forty 100-ft rolls, maintaining hypo under 4 micrograms/sq in.

3. Spray-Washing Tests

The application of K.H.C.A. to spray processing was investigated by Turner and Jensen, using Eastman Fine Grain Release Positive Film, Type 5302, with laboratory equipment recently described by them.[12] Following normal processing procedure, including final fixation in Kodak F-5, the films were either (a) spray-washed for a series of times or (b) spray-rinsed for 15 sec, sprayed with K.H.C.A. for 10 to 60 sec, and then spray-washed. The water and K.H.C.A. were applied at 70 F, passing through a K-5 nozzle at 10 psi, and with a spray-pass frequency of 55/min.

The K.H.C.A. strikingly accelerated washout when applied under these conditions of high agitation, as indicated in Fig. 5. The Fine-Grain Positive Film was washed down to the archival level of 5 micrograms/sq in. by either a 20-sec treatment with K.H.C.A., plus a 45-sec spray-wash or by a 40-sec treatment and 15-sec wash, while 8 min of unaided

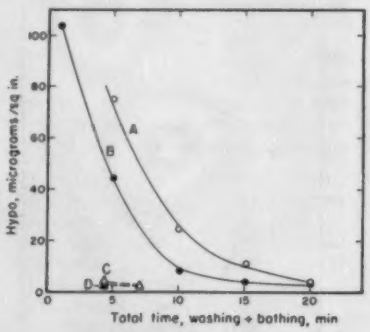

Fig. 6. Washing on the spiral reel. Solid lines apply to unaided washing; the dashed lines, to washing after first bathing for 2 min in K.H.C.A. Curves A and C are for 42 F water; curves B and D, for 68 F water. Data obtained with Kodak Micro-File Film.

Table IV. Rewind Processing (9½-In. Kodak Super-XX Aero Film in 5-Gal Fairchild-Morse Rewind Tank).

Feet processed	Hypo (Micrograms/sq in.) following wash of			
	10 min	20 min	30 min	5 min*
75	160	84	36	7
150	—	—	—	20
275	—	—	—	3
475	—	—	—	18
885	—	—	—	52

*Bathed 100 sec each in water rinse and K.H.C.A. before washing.

spray-washing still left 15 micrograms/sq in., or three times the desired hypo level.

4. Small-Scale Processing Procedures

(a) *Spiral Reel.* Short lengths of motion-picture film are occasionally processed on spiral reels holding 30, 50, or 100 ft of 35mm film. This type of processing is also important in microfilming. Experiments were run with 30-ft lengths of microfilm fixed in fresh F-5 and washed at a high rate of flow (12 changes per hour). The data obtained with unaided washing, as shown in Fig. 6, are given by curves A and B. Approximately 20 min were required at 42 F, and 12 min at 68 F to reach the archival level of 5 micrograms/sq in. Curves C and D apply to film first bathed for 2 min in the K.H.C.A. salt bath and then washed. In this case, the washout was extremely rapid and all values are below 5 micrograms/sq in., regardless of water temperature.

(b) *Rewind Equipment.* Rewind equipment, made by the Morse Instrument Co., is used for processing lengths up to 150 ft of motion-picture film, microfilm, fluorographic film and aero film. These experiments used 9½-in. Kodak Super-XX Aerographic Film in a tank of 5-gal capacity, but the results obtained can be scaled down to smaller tanks by direct proportionality, and would apply essentially to other high-speed negative films. The film was developed for 8 min in Kodak Developer DK-50, rinsed for one pass (50 sec) through an acid stop-bath, and fixed in Kodak Fixing Bath F-6 for 15 min. The effect of unaided washing was compared with a procedure in which the film was rinsed, bathed in K.H.C.A. and washed. The flow of water allowed ten changes per hour.

The F-6 fixing bath, owing to its relatively high pH value, has good washout characteristics, and Table IV shows that hypo levels were reduced to as low as 36 micrograms/sq in. by 30 min of unaided washing, but bathing in the K.H.C.A., followed by a 5-min wash, reduced the hypo level down to 7 micrograms/sq in., and the level was maintained under 20 micrograms/sq in. when processing up to 700 ft of the 9½-in. film (per 5 gal).

In another variation, the running-water wash was replaced by a tank of stagnant water, to simulate possible processing under conditions of acute water shortage. The hypo level of the first 100-ft roll of film was 94 micrograms/sq in., which meets the usual "commercial" tolerance for high-speed negative film. However, it was necessary to replace this final water rinse after processing each roll.

Recommendations

The adaptation of a salt bath to hypo elimination in any given process will vary with many factors, including agitation, limiting times and capacities of the machine, the hardening action of the fixing bath, the quantity of hypo tolerable, the film employed, and the nature of the salt bath. Capacity will be influenced by carry-over, contamination with hypo and sludging. However, basic recommendations may be made for the highly efficient Kodak Hypo Clearing Agent as follows:

(1) Rinse the film, if at all possible, as with a water knife or a spray after fixing.

(2) Bathe the film in K.H.C.A. for 1 to 2 min in a tank process, or for 15 to 45 sec in a spray process.

(3) Wash for about 5 min in a tank or for 1 min in a spray.

(4) Replace the bath after each 1000 ft of 35mm film per gallon, or replenish it at 1 gal/1000 ft. If no water rinse is available, capacity will be about 300 ft/gal.

(5) Test the processed film with mercuric chloride or silver nitrate, as per References 9 and 10. Failure of the silver nitrate test to produce a visible spot on films processed with K.H.C.A. may be frequently anticipated and indicates washing superior to the usual archival standard.

Acknowledgments

The authors wish to thank their coworkers, Nancy H. King, G. McWilliams, E. W. Jensen and J. R. Turner, for supplying data used in this paper.

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Discussion

Irving Streimer (Pathé Laboratories): Are the concentration and washing time in the spray treatment reciprocals of each other? Can you say, for example, that an increase to 10% in the amount of salt would cut the spray time down from 15 seconds to 5 seconds or 3 seconds?

Mr. Crabtree: If you question whether there is direct proportionality between concentration and time, I wouldn't say so. The optimum useful concentration I would say is about 2%, but if you were to go up to 10%, I don't think you would improve the effectiveness more than maybe 25%.

Robert E. Johnson (Byron, Inc.): Is the hypo estimator applicable to the blue-base films or is any compensation made to take care of the base color?

Mr. Crabtree: Since both the test spot and the comparison scale are viewed through the blue base, no compensation is necessary.

Ralph Haburton (U.S. Air Force): In the motion-picture data given, what was the pH of the fixing bath?

Mr. Crabtree: Around 4.5.

Clifford Bourne (Shelly Films Ltd.): I assume that continuous replenishment is quite feasible with the clearing bath at half a gallon per thousand feet?

Mr. Crabtree: That's right. Actually, in our machine, we discard it weekly, and do not bother with replenishment, since the level is not affected when the carry-in is equal to the carry out.

Monochrome TV Lighting Survey and Report

By WILLIAM R. McCOWN

The Television Studio Lighting Committee agreed at its meeting at Chicago, April 21, 1955, that information on black-and-white lighting practices of television stations would be of help in furthering committee projects. The Midwest Regional Subcommittee was then assigned to conduct a survey of 341 stations in 25 States, the results of the survey to be presented at a lighting symposium to be held in the Spring of 1956.

PERSONAL VISITS to the stations were impractical, so a questionnaire was prepared and sent to the list of stations, along with a covering letter to explain its purpose. Of the 341 sent out, about 45%, or 155, were returned — a much higher percentage than was expected. Of these 155, one had no television station, 3 were returned because of insufficient address, 3 had gone off the air, 4 had relinquished their permit or grant and 10 were not yet on the air. This left a total of 134 valid questionnaires.

Lack of Standard Terminology Noticed

Some of the questions were misunderstood because of lack of standard terminology and phraseology and answers to these had to be discarded. In spite of this, a great many facts were observed.

ANSWERS TO QUESTIONNAIRE

The following is an outline of the questions for which, with a few exceptions noted, the composite answers have been integrated.

I. Studios

1. Number of studios?

Of the 134 stations answering: 57 had 1 studio, 65 had 2, 8 had 3, 2 had 4, 1 had 5, and 1 had 6. The average number of studios was 1.78 per station.

2. Size of Studios — by largest, by smallest and also by number of separately lit areas of largest studio?

The average size for the largest studios was 2,111 sq ft. The average for the smallest was 824 sq ft. There were 6 average separate areas per station.

3. Is a rear-screen system used? What wattages of incandescent lighting? What size of rear screen?

Of the stations answering, 51% were using a rear screen. None of the stations had arc equipment. All were using incandescent as follows:

1000 w, 5.97%	2500 w, 4.48%
1500 w, 4.48%	3000 w, 5.97%
2000 w, 25.37%	4000 w, 4.48%
2100 w, 38.81%	5000 w, 13.43%

Some stations had more than one rear screen, usually a very small second one. When there was a smaller one it was disregarded in the tabulating of the following (dimensions in feet):

1 of 5 × 6	1 of 10 × 14
1 " 7 × 9	2 " 12 × 14
24 " 8 × 10	1 " 12 × 15
29 " 9 × 12	2 " 12 × 16
1 " 9 × 14	1 " 12 × 20
6 " 10 × 12	Avg. = 9 × 12

II. Lighting Materials

1. What kind of light? Fluorescent? Incandescent?

No station used fluorescent exclusively; 40% of the stations used both, fluorescent and incandescent, with incandescent noted on most of the questionnaires as being most frequently used. The remaining 60% used incandescent entirely.

2. If both are used, which is more frequently used and which is preferred?

Of the stations which reported, 98% used incandescent more frequently and preferred it.

3. If incandescent light is used, what type of lamp fixture is employed? Spots, scoops or broads?

This was a question where lack of uniformity in terminology caused some misunderstanding, most noticeably in respect to "broads." If it was felt that the question was misunderstood the answer given was not used. No station used spots exclusively; two used all scoops; no station used broads exclusively; 99 used both spot and scoops; and 33 used all three types listed.

4. Which of the above is most frequently used?

Of the 131 answers, about 23% stated that spots were most frequently used; 60% scoops; 3% broads and 14% stated that equal numbers of the various types were used.

5. What type of illumination is preferred — hard or specular (from spots), soft or flat (from scoops or broads)?

This question was perhaps the most misunderstood of all. Most of the answers had to be discarded, and the few that remained were too varied in their answers to be listed. A few examples follow: "type of show determines which is used" — "use both as occasion demands" — "type of show" — "depends on set" — "both are used on every show; no hard spots except for effects, musicals, etc." — "this depends on what sort of effect we are trying to create" — "use both" — "type of show determines which is used."

6. What is the largest lamp used (wattage); spot, scoop, broad and any other type?

There was quite a variety of wattages listed, some studios listing the highest of all types at 500 w and some few going as high as 5,000 w. Some stations listed 650 w, 1200 w, 2200 w, 4000 w, and higher. It was felt that some of these sizes were odd for particular types and these were changed to the closest standard size.

Table I shows the information obtained. Figures given indicate percentages of totals using types of fixtures: column (1) indicates number of stations using particular fixture; column (2) indicates the percentage of total station returns using fixtures.

7. To what extent (if any) are PAR reflector-type lamps used?

This is another question in which the terminology used caused a misunderstanding. The useful answers seemed to indicate that this type of lamp is used mostly for backlighting and in groups for fill.

8. What is the maximum light wattage of the largest studio?

The answers to this question were quite varied and therefore are not listed,

Table I. Lamp Types and Sizes, in Watts.

Type	500	750	1000	1500	2000	5000	(1)	(2)
Spot	8.33	9.84	28.78	16.66	34.84	1.51	132	97.05%
Scoop	3.84	3.07	33.07	48.46	11.53	0.00	130	95.58%
Broad	0.00	0.00	38.46	23.07	38.46	0.00	13	9.55%
Follow spot	0.00	0.00	0.00	0.00	100%	0.00	3	2.20%
Sun spot	0.00	0.00	0.00	0.00	100%	0.00	1	0.73%

Presented on May 2, 1956, at the Society's Convention at New York by William R. McCown, Chairman of the Subcommittee, WSM-TV, 15th and Compton, Nashville 12, Tenn.
(This paper was received on March 5, 1956.)

the range being from 10,000 w to better than 300,000 w. The average wattage for the 109 answering is 50,338. Only a few of the stations indicated whether total wattage listed was connected load, circuit wattage, or actual amp load. Watts per square foot were figured for each station, based on the information supplied and listed on each individual questionnaire. These ranged from a low 5 w/sq ft to above 100 w/sq ft.

9. Are "barn doors" or diffusers regularly used?

Of the 132 answering this question, 112 used some sort of fixture attachments all or most of the time; the rest didn't use them to any extent.

10. Are dimmers employed; what percentage of circuits can be dimmed; how many sets or banks of circuits can be turned on from one switch?

Of the 132 answers, 53 reported the use of dimmers. The average percentage of circuits with dimmers was 49% with the answers running from as low as 5% to as high as 100%. Answers about the sets or banks varied with relation to the answers to question 11 and therefore are not listed.

11. West patch equipment, dimmer board — if purchased from a manufacturer, what make, size in circuits; or if made for or by the station; what size in circuits?

Of the 60 stations answering question 11, 44 had obtained manufactured equipment, some of which had been modified to their own specifications. With the exception of two answers (208 and 220 circuits respectively) which it was felt would throw off the average, manufactured equipment averaged 40 circuits per installation, with answers running from 6 to 96 circuits. There were 16 stations of the 60 who had either made their own equipment or who had had it made for them locally. Stations that made their own equipment also averaged 40 circuits per installation (one 180-circuit answer was not used) with answers running from 8 to 70 circuits.

III. Personnel

1. Is there someone specifically assigned to direct studio lighting (not to handle, but to supervise)? If so, is this lighting director in the production or engineering department and does this person have formal training (or background as a hobbyist) in the theater, fine arts, photography or in other words does he have the knowledge of basic lighting principles?

Of the stations reporting, 78 or 58% employed a lighting director. Of these 78, 51 were in the production department, 25 were in engineering, and 2 did not designate as to training, one failed to reply, one answered "no," two answered "all TV training" and the rest all replied "yes." There were some comments to this question that might be of interest: "this man is the senior stagehand, who also functions as staging crew chief, since lighting does not occupy his full time" — "engineer placed in production department" — "number of directors and cameramen have experience in photography giving them good background for TV lighting."

2. Is the management satisfied with the lighting setup as it is? If not, what changes or improvements would you suggest?

On this question, 3 stations failed to answer, 66 answered "no," the rest, "yes." Several of the affirmative answers, however, included improvement suggestions which are abstracted and shown under "General Comments" below.

3. Would the management or personnel welcome any assistance or advice which the Committee may have to offer as a result of this survey?

Only one of the total questionnaires used failed to include an answer to this question. The rest were *all* answered in the affirmative, most being a simple "yes," some more emphatic. Several comments were made, these being the most important: "Would like very much to have assistance, advice, information on new light, equipment, etc." — "We would gladly accept any help or advice on lighting" — "We would certainly welcome any assistance in bettering our lighting conditions as this is one of (the) lacking essentials needed in our present operation" — "So little has been written or made available. The great need is for operational data, more than facilities design" — "We certainly would, I have been concerned with the lack of material available" — "If copies of your. . . paper are available. . . would appreciate one" — ". . . information. . . presented at symposium . . . on TV studio lighting . . . would be gratefully received."

IV. General

1. What are the most common "headaches" or difficulties you have encountered with TV lighting?

The 16 commonest complaints are listed in descending order of incidence:

1. Lack of sufficient lighting instruments and units.
2. Lack of patch equipment, dimmers, circuits, etc.
3. Lack of time for rehearsal and for setting of lights.
4. Inadequate use of light. Need for improved modeling with key light and back light.
5. Inability to properly light rear-screen scenes due to low illumination level of projection system. This was listed by almost all stations who used a rear screen.
6. Different light levels from one set or scene to another and from one camera angle to another.
7. Lack of cooperation between engineering and production. (This was bluntly brought out in some of the answers.)
8. Mike boom shadows.
9. Lack of studio and/or ceiling height.
10. Lack of specular (or hard) illumination. Quite a few stations recommended use of more spots and less scopes.
11. Inflexibility of lighting system, units, grids, etc.
12. Lack of proper control over lighting units.
13. Improper camera alignment or control. Difference between various image-orthicon tubes.
14. Hot spots and reflections on various objects.
15. Lack of know-how and standardization.
16. No trained personnel, or, personnel being utilized not taking the time or the pains to do the best with available material.

General Comments

Some interesting comments are given below:

"Many stations will invest considerable sums in equipment and personnel to improve lighting and then put inadequately trained men into video operation positions, for economy reasons. Obviously this is false economy."

"The greatest problem which we seem to have is consistent camera control. At times our lighting seems to achieve excellent quality and at other times with virtually no change in lighting setup there is considerable variance. To the extent of this inconsistency, light is sometimes criticized."

"As a comment to . . . [the] survey I might add that to me the greatest need on the local level is a standardized listing of comparative lens-opening scales to be shown with foot-candle ratings. A chart such as this should better explain the relationship of light intensities with use of standard equipment."

"It is quite difficult to set up any standardization of your own when the industry itself seems confused."

"We are constantly searching for equipment designed specifically for TV and a standard technique which will enable our cameras to maintain a constant level of quality as opposed to 'effect lighting.'"

". . . the big problem is to get members of the production crew to take time to properly light a set. The general procedure is to turn on every light in the studio."

"[the problem is] . . . getting production people educated in the use of proper stage setups, in regards to best lighting, and the elimination of a simple show moving all over the studio."

"By far the biggest single headache is that staff members, engineering and production alike, do not understand the equipment they are working with, and therefore do not understand the basic requirements of lighting a picture to be picked up by this equipment. Regardless of whether or not he has an artistic

background, the man who thoroughly understands the characteristics and limitations of the image-orthicon tube is a lighting expert. If all our people had this knowledge, we could do a good job of lighting with kerosene lanterns. I cannot over-emphasize this point. The man who does not understand the image orthicon cannot do a first class job of lighting regardless of how much experience he has had in stage, photography or any other field."

"This is a fairly large city, with a fine library system, but I have completely exhausted the information available on TV lighting. One point I think which strikes me as strange is the lack of agreement among different experts on TV light. I sincerely hope the study you are making will come up with ideas for the very inexperienced in the TV lighting field, of which I am a charter member."

Observations

In the process of going over the returned questionnaires, many things were observed, the most noticeable being a lack of understanding and unification of terminology. As noted above several answers had to be discarded because of this. It is understandable that this might happen when radio and allied fields are suddenly thrown into a world of "lenses," "lights" and "film"; and, when artists, cameramen and motion-picture technicians suddenly find themselves greatly concerned with "image-orthicon limitations," "compressed white levels" and "television grays." A common groundwork or understanding must be established so that help may be given to those seeking it.

Secondly, the fact that all stations replying to the survey were willing to accept help in their lighting, whether or not they felt they had problems, was revealing. Some stations were almost at the point of begging for aid of some description.

Although one could think of many more questions, it is felt that this survey did gather some useful information, and that that information will be of help in furthering the aims of the television industry. To that end this survey and report are submitted and thanks extended to all the stations and people taking time to help on this project.

Color TV Lighting Survey and Report

By GERALD F. RESTER

A survey of current lighting practices of TV stations engaged in live color origination was requested by the Television Studio Lighting Committee of the SMPTE. Seven major categories were covered: General, Studios, Lighting Materials, Personnel, Instrumentation, Make-up, and Miscellaneous. The main purpose of the survey was to determine the areas where independent and affiliated stations could benefit from assistance and advice. It was planned that after these areas were defined, SMPTE Lighting Subcommittees would be assigned specific areas for investigation.

LATE IN 1955, the Television Studio Lighting Committee of the SMPTE requested that a survey be made of current lighting practices on live color television. In the opinion of the committee, such a survey would serve as a valuable tool in arriving at a definition of the areas where advice and assistance would be of benefit. It was planned that after the results of the survey were tabulated, SMPTE Lighting Subcommittees would be assigned to the various "weak" areas to conduct more detailed investigations.

At the time the questionnaires were submitted, 12 stations were selected. These stations had operated their lighting equipment long enough to have established their lighting routines sufficiently to report results with value to the survey.

Presented on May 2, 1956, at the Society's Convention at New York by Gerald F. Rester, Commercial Electronics Products, Radio Corp. of America, Camden 2, N.J.
(This paper was received on May 28, 1956.)

Table I. General Information.

Station	Cameras in use	Weekly program hours	Weekly rehearsal hours	Normal type of show	Footcandles incident light: Usual base	Usual key	Usual back light
A	1	2	5	Women's; variety	—	400–500	350
B	2	1.5	1	Cooking; variety	300	600	300
C	2	10	5	Women's; variety	400	425–450	450
D	1	3	3	Women's	300	to 500	150–200
E	1	2	6	Closed circuit	500	600	650
F	2	5	7.5	Homemaking; variety; interview	200	400	600
G	1	2.5	—	Kitchen	300	—	—
Minimum	1	1.5	1.0		200	400	150
Maximum	2	10.0	7.5		500	600	650
Average	1.4	3.7	4.6	Women's; variety	330	500	420

Table III. Lighting Materials.

Station	Type lighting: Incandescent	Type lighting: Fluorescent	If both inc. & fluor.: Predominates	If both inc. & fluor.: Preferred	Types incan. used: Spots	Types incan. used: Scoops	Types incan. used: Broads	Predom. type fixture	Prefer: Hard	Prefer: Soft	Largest lamp—kw: Spot	Largest lamp—kw: Scoop	Largest lamp—kw: Broad	Largest lamp—kw: Other
A	√		—	—	√	√	√	Scoops		√	2	1	1.5	
B	√		—	—	√	√		Equal scoops & spots	—	—	2	1		
C	√		—	—	*√	√		Equal scoops & spots		√	5	2		†0.3
D	√	√	Incand.	Incand.	√	√			Depends on program		5	1		
E	√		—	—	√	√		Spots	Key & back	Base	2	1.5		
F	√		—	—	√	√	√	Spots	Key	Base	2	1.5	1.0	
G	√	√	Incand.	Incand.	√			R-40	√		0.75	—		0.3 R-40

* Also uses TV Associates Banks, half R-40, half Par 38.

Table II. Studios for Color.

Station	No. studios for color	Largest color studio	Smallest color studio	No. of sep. lit. areas-largest studio	Rear proj. used?
A	2	—	—	3	No
B	2	2070	528	5	No
C	1	3690	3690	3 Sides	No
D	5	1620	156	4 Sides	Yes
E	1	2080	2080	4	No
F	2	2400	2400	2–4	Yes
G	2	2400	1200	6	No
Minimum	1	1620	156	2	—
Maximum	5	3690	3690	6	—
Average	2.1	2377	1676	4	—

At present more than 20 stations not owned by the networks have taken delivery on RCA live color cameras. The survey did not include network-owned stations, but covered only independent and affiliated stations. Seven questionnaires were returned. Compilations of the answers received in the various categories are given in Tables I–V.

I. General (Table I)

Besides the statistics summarized in Table I, it may be noted that the general questions also covered the three basic categories of studio lighting, defined as:

(*1*) *Base Lighting:* Uniform, diffuse illumination, approaching a shadowless condition sufficient for a TV picture of technical acceptability, and which may be supplemented by other lighting.

(*2*) *Key Lighting:* The apparent principal source of directional illumination falling upon a subject or area.

(*3*) *Backlight:* Illumination from behind the subject in a direction substantially parallel to a vertical plane through the optical axis of the camera.

These basic types of lighting are summarized in Table I.

II. Studio Facilities (Table II)

Most of the stations were found to be laid out in such a manner that more than one of their regular monochrome studios could be used for color merely by lighting it appropriately and rolling the color cameras into the studio. The largest studios for color varied in size from 30 ft × 54 ft to 82 ft × 45 ft, with the average of the largest studios 2377 sq ft. The smallest studios ranged from 12 ft × 13 ft to 82 ft × 45 ft, the average being 1676 sq ft. The stations were found to use 2 to 6 separately lit areas or sets in their largest studios. Two stations reported using a rear screen projector for color. One uses a 5-kw incandescent unit on a 9 ft × 12 ft screen and the other a 2-kw incandescent unit on a 7 ft × 9 ft. screen.

III. Lighting Materials (Table III)

Many generalities, such as that all the stations reported using incandescent lighting, will be noted in Table III. Two stations prefer soft or flat lighting from scoops or broads, while two reported a preference for flat lighting for base and hard or specular lighting for key and back lighting. One prefers hard lighting to soft, while a sixth determines preference by program content.

In reply to questions on the largest lamps used, in the spotlight category 2 stations reported 5-kw, 4 reported 2-kw, and 1 reported 750-w. The largest scoop lamps used are 2-kw in 1 station, 1500-w in 2 stations and 1000-w in 3 stations. The two stations using broads reported maximum sizes of 1500-w and 1000-w. Three stations use PAR reflector lamps and 3 do not.

Four stations were found to use dimmers in lighting for color. The 4 using them can dim from 33⅓ to 100% of their circuits. Five stations reported on the number of sets or banks of circuits that can be energized from 1 switch, replies ranging from 1 to all. Two of the 4 stations equipped with dimmers have standard television equipment, 1 has equipment made locally, and 1 has a composite system. It may be assumed that the 3 stations without dimmers have all circuits or small circuit groups wired to individual switches or circuit breakers.

IV. Personnel (Table IV)

The overall facts are shown in Table IV. One studio did not have a regularly assigned lighting supervisor, but used personnel from the production department whenever necessary. Stations having a lighting supervisor reported that he has formal training, or background as a hobbyist, in the theater, fine arts or photography, and possesses a knowledge of basic lighting principles. Five stations reported that the engineering management is satisfied with their present lighting setup, and the sixth reported that the present lighting capacity should be doubled.

V. Instrumentation (Table V)

All the stations were found to use light meters. Four stations reported a preference for incident light measurement and one reported partiality toward brightness type of measurement. Only one station reported the use of a color temperature meter.

VI. Make-up

Five stations reported the use of special make-up for color, and three use Max Factor Color TV Series. Two stations do not use special make-up for color.

VII. Miscellaneous

Miscellaneous headaches encountered in lighting for color included: Too much light required, causing excessive heat in summer; difficulty of obtaining and maintaining even light intensity throughout staging area; boom shadows; backlight bleed on faces; preserving skin tone; low-key lighting; some sets difficult to light; sufficient time must be allotted to light properly; shifting of fixtures with change of sets; maintaining even light distribution over entire set consistently.

Table III (concl.)

Station	Are par refl. lamps used?	Max. wattage largest studio	W/sq ft largest studio	Are barn doors, diffusers, etc., regularly used?	Dimmers used?	% circuits can be dimmed	No. of sets or banks of circuits energized one switch	Patch and dimming equipment
A	No	90 kw	—	Yes	No	No		Switching only, local mfr
B	Yes (backlight)	100 kw	48	Yes	Yes	50%	5	120 switching circuits, local mfr
C	†Yes	216 kw	58.5	Yes	Yes	33⅓%	10	12 dim., 12 no-dim. circuits, rotary selector switches, nat'l mfr
D	No	100 kw	61.5	Yes	Yes	100%	12	
E	No	150 kw	72	Yes	Yes	50%		72 switching circuits only, nat'l mfr 12 4000–5000 w dimmers 96 circuit plug & jack cross connect
F	—	60 kw	25	Yes	No	No	All	36 switching circuits only
G	Yes	48.2 kw (Avg. 109.2 kw)	20 (Avg. 47.5)	Yes	No	No	1	

† In TV Assoc. Lamp Banks.

Conclusions

Six of the seven stations surveyed said that they would welcome assistance and advice on live color lighting. It is suggested that the SMPTE Lighting Subcommittee on Instrumentation survey the field of instruments available for incident lighting and color temperature measurements, compiling a list of recommended and practical specifications for these instruments. Recommendations should also be made as to uniform methods and procedures for using these instruments. The importance of uniform color temperature throughout a set cannot be over-emphasized.

It is possible that new fixture and lamp designs would be helpful. Although fluorescents give fairly flat illumination, they should not be used in combination with incandescents in lighting for color because of a different spectral response.

Although advice and assistance are needed in certain areas, it appears that lighting for color presents no great difficulties provided a few basic rules are followed.

Table IV. Personnel.

Station	Regular lighting supervisor assigned?	Lighting supervisor prod. or eng.?	Lighting supervisor formal training?	Management satisfied?	Lighting improvements suggested by chief eng.	SMPTE recommendations welcome?
A	Yes	Prod.	Yes	Yes		Yes
B	No	—	—	Yes		Yes
C	Yes	Prod.	Yes	Yes		Yes
D	Yes	Eng.	Yes	Yes		Yes
E	Yes	Eng.	Yes	Yes		—
F	No	Prod. (when assigned)	Yes	No	Double present lighting capacity	Yes
G	Yes	Prod.	Yes			Yes

Table V. Instrumentation.

Station	Use meters?	Kind	Prefer incident or brightness?	Color temp. meter	Kind of color temp. meter
A	Yes	Weston-fc	Brightness	No	—
B	Yes	Weston	—	No	—
C	Yes	SEI brightness GE incident	Incident	No	—
D	Yes	GE	—	No	—
E	Yes	Weston-fc	Incident	Yes	Rebikoff
F	Yes	GE	Incident	No	—
G	Yes	Norwood directors Weston-fc	Incident	No	—

Discussion

Charles Shevlin (Century Lighting Corp.): What is the definition of the broad?

Mr. Rester: An example of a broad was shown in the CBS film which preceded these papers. It's an instrument which is more commonly used in the movies and gives fairly flat illumination.

Anon: They vary in size. The term broad is merely shortened from the so-called broadside illuminator, and originally they used to have two arcs, within this diffuse, not necessarily optically formed reflector, so that the type of illumination you got was essentially a broadside illumination from a large, diffuse source.

Richard S. O'Brien (Session Chairman): I think it's interesting to note that in both of these surveys the 1500- or 2000-watt scoop seems to be rather a workhorse of the lighting business for television. Apparently from what you said the station reporting excess heat does not do color television in the summer, is that correct?

Mr. Rester: It's limited somewhat. On the hottest days apparently they limit their programs to short periods at the particular station concerned.

George T. Howard (General Electric Co.): Did the stations report actual troubles or differences in trying to use fluorescent and incandescent intermixed?

Mr. Rester: They didn't indicate such, but I suspect that there's a trouble there that they haven't recognized as such as yet. The purpose of this survey was to find out what people are doing, so that they might receive suggestions on how to improve their techniques.

Mr. Howard: We have been curious about whether this problem is recognized. We've seen it and know what it is when we see it, but some don't.

Editorial Note: These survey reports were the basis for much of the planning for the three Television Studio Lighting Sessions at the New York Convention. Of the 21 items in those sessions, 1 item was a film and 5 were papers not formally presented. Of the 16 remaining items, 4 in addition to the reports above are at hand for early publication. TV studio lighting papers will be published as soon as available in finished form. There is a tentative plan to gather these papers for a composite reprint.

news and reports

Charles S. Stodter has been appointed Executive Secretary of the Society, succeeding Boyce Nemec who resigned as of June 15 to open a management consulting service. Announcement of Stodter's appointment was made June 11 by John G. Frayne, SMPTE President.

The new Executive Secretary has had extensive engineering and administrative experience with motion pictures and television. He served 30 years in the U.S. Army and during that time administered various Army pictorial activities. After his retirement in 1954 at the age of 51 with the rank of Colonel, he was appointed Senior Research Investigator with the Institute for Cooperative Research of the University of Pennsylvania. He was chiefly engaged in the study of communications systems in relation to advanced military weapons.

From 1950 to 1954 Col. Stodter was Chief of the Army Pictorial Service, Washington, D.C. He administered all Army pictorial activities during the Korean War including still photography and motion-picture and television used for training and other military purposes.

From 1948 to 1950 he served as Commanding Officer of the Signal Corps Pictorial Center, Long Island City, N. Y., where he dealt with all aspects of Army motion-picture production and distribution. At the time of his appointment in 1948, the Army had just begun to make use of television as a valuable adjunct to training and tactical operations. He was Deputy Chief of the Army Pictorial Service in Washington from 1943 to 1945 and was the principal assistant in the administration of the wartime world-wide Army photographic services.

Mr. Stodter studied motion picture techniques under a program sponsored by the Motion Picture Research Council in Hollywood. He has also been affiliated with the motion-picture industry as Liaison Officer in charge of the production of military training films, and has served as Commander of the Signal Corps Still and Motion Picture Laboratories at Washington, D.C. He is a graduate of the Massachusetts Institute of Technology and holds a Master of Science degree in electrical engineering.

80th Convention Plans

Reports coming in from Pete Vlahos, Program Chairman, indicate that a very full and business-like convention is shaping up for the fall. To be held at the Ambassador, Los Angeles, October 8–12, the 80th Convention will have 15 sessions, including 4 evening and 2 concurrent. A tentative grouping of topics has already been made, and around it the eventual program will be built:

(1) *Motion-picture art, engineering and practice* (production, photographic processes, equipment, techniques, etc.);

(2) *Television* (advances in color, color receivers, kinerecording, magnetic video recording, etc.);

(3) *Instrumentation and high-speed photography* (aeronautical, military, data reduction, ballistics, etc.);

(4) *Exhibition and projection* (equipment, film cooling, lens, screens);

(5) *The laboratory of today and tomorrow* (new labs, automation, printing, processing, etc);

(6) *The 16mm art* (magnetic striping, standards, equipment production, duping and printing, 16mm CinemaScope, etc.);

(7) *The basic elements* (transistors, new emulsions, new color processes, recording techniques, etc.).

A definite commitment has been made by Ampex for a full technical description, with demonstrations, of their video tape recording process. Other papers planned are Technicolor's large negative process, the Disney Westrex editor, process screens, the VistaVision double-frame process projector, color kinerecording, xenon lamps for theater projections, automation at General Film Laboratories, and transistor developments

Don't hesitate, write now about Convention paper prospects or suggestions to:

Petro Vlahos,
80th SMPTE Program Chairman,
Motion Picture Research Council,
6660 Santa Monica Blvd.,
Los Angeles 38, Calif.

Equipment Exhibit

Progress toward organizing the equipment exhibit is also well ahead. Under the chairmanship of John B. Olsson of Houston Fearless, arrangements have been made with the Ambassador for some very fine exhibit space in the newly renovated section of the hotel. Present plans are for 43 booths, which will be almost double the area of the last exhibit held in Los Angeles in 1954. Enthusiasm ran high among exhibitors at the Spring Convention this year in New York, and indications are that space will not be left available long at the Ambassador. Brochures and order forms will be out about the same time as this issue of the *Journal*. Meantime, anyone needing details about space or prices should write to John B. Olsson, SMPTE Exhibit Committee Chairman, % Houston Fearless, 11801 W. Olympic Blvd., Los Angeles 64.

Education, Industry News

The contract for a new building designed for 20th Century Fox Film Corp.'s 55mm CinemaScope film production has been awarded to the Los Angeles consulting engineering firm of George J. Fosdyke. The building will house reviewing and sound dubbing operations. Plans are for a 2-story building 75 × 218 ft. An interesting feature of the new building will be tilt-up panels of reinforced concrete 29 × 33 ft and only 5½ in. thick.

Expansion plans for CBS Television City, Hollywood, call for the construction of two studios and 8 rehearsal halls. A 9-story office building will be erected to house administrative and creative personnel. Part of a long-range plan proposed when Television City was designed and built in 1952, need for additional facilities was anticipated because of the growing trend toward longer and more elaborate programs.

As part of the expansion plan, CBS is expected to install the new Ampex video tape recorder at an early date. The new studios will be fully equipped for both color and black-and-white broadcasting, and one of the existing studios will be fully equipped for color.

Provision for a high school TV studio is included in New York City's school building and planning program for 1957. The new studio, believed to be the first of its kind, is included in plans for the new George Westinghouse Vocational High School at Tillary and Bridge Sts., Brooklyn. The studio will supplement educational programs by broadcasts over the school's closed circuit system and will be used in courses on TV production and techniques under the supervision of a staff selected from the Board of Education's station, WNYE.

Dick Tracy with his two-way wrist radio would feel like a doddering old fossil if he attempted to do any sleuthing at this

year's national political conventions. His obsolete detecting device would possibly turn out to be competing with hip pocket wire recorders that can be booked up to microphones disguised as wrist watches, tie clasps or even cuff links, portable TV cameras that can be carried by one man, and pocket-size two-way radios. Every detail of the conventions will be covered by the major networks. NBC has been reported to be insuring its convention staff and equipment with Lloyd's of London for $5,000,000.

George Gill has been appointed manager of Century Lighting Inc.'s newly opened Southern Branch at 1485 N.E. 129 St., North Miami, Fla. He is a member of SMPTE and of the Illuminating Engineering Society, and has been associated with the specialized illumination and theatrical lighting fields since 1931. One of the major services of the new branch is the rental department. A representative stock of Century's theatrical supplies and lighting equipment will be maintained on the premises.

Albert A. Chesnes has been appointed Technical Director of Chromatic Television Laboratories, Inc., 1501 Broadway, New York. Announcement was made by Robert Dressler, Vice-President.

Chromatic is a research and development organization affiliated with Paramount Pictures Corp. Its main commercial interest is the development of the Chromatron or "Lawrence tube," a single-gun color TV picture tube and its associated receiver circuitry. In his new post, Chesnes will be responsible for the overall supervision of Chromatic's color development program and for its military electronics activities.

James B. Faichney, Associate Producer of CBS-TV *Air Power* series is in Europe to secure film purchase agreements in England and on the continent for material to be used in the *Air Power* series. Faichney was formerly with the U.S. Information Agency and had charge of all overseas motion-picture production for that agency.

The Elsevier Publishing Co. of Amsterdam has granted distribution rights to the D. Van Nostrand Co., 120 Alexander St. Princeton, N. J., for the United States, Latin American Republics and the independent nations of Asia. The Elsevier line now comprises approximately 100 titles of scientific and technical works published in Europe, and from 15 to 20 new titles will be added annually. A new short title catalogue of Elsevier publications will soon be available.

"What's Available on Microprint Cards" is an 8-page pamphlet resulting from a survey of all publishers known to be active in the microprint field. The booklet classifies the information by subject fields and tells where purchases may be made. Microprint editions of reference works in various branches of science enable the research scholar to have access to rare, costly or out-of-print literature. Various government reports, patents and business reports are available in microprint card editions. Copies of the pamphlet may be had on request to Graphic Reproduction Div., Eastman Kodak Co., Rochester 4, N.Y.

Lifelong Learning is a folder which briefly describes two new films now added to Lists 1–4 of the University Extension, University of California, 405 Hilgard Ave., Los Angeles 24. The new films, *The Foreman Discovers Motion Study,* and *Introduction to Work Sampling,* are of special interest to industrial engineers and students. Other films produced by the extension service are on subjects related to the theater, arts, science, engineering and other educational subjects. The films are for sale or may be rented. Preview prints are available to organizations interested in purchasing.

Department of Commerce Report

Motion-picture theater admissions reached a peak of $1.7 billion in 1946 followed by a steady decline through 1953. A rise in 1954 and 1955 was not enough to offset the sharp drop which cut boxoffice receipts 25% below the peak level. The decline in the number of admissions was proportionately greater than the drop in receipts because the index of admission prices had risen 30% by 1955.

This information is contained in a Commerce Dept. publication, "Survey of Current Business, May 1956." The report may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., for 30 cents.

The report makes no attempt to interpret these figures, but the sharp drop in motion-picture income at a time when other forms of recreation were on the upgrade makes for critical speculation. It is obvious that the decline in motion-picture receipts coincided with the upswing in TV sales. This has been interpreted by some persons to mean that the younger industry was crowding out the older, although others stoutly maintain that the one trend had nothing to do with the other.

Jerry Wald, Executive Producer, Columbia Pictures, in an address delivered before American Cinema Writers 6th Annual Awards Banquet at Beverly Hills, Calif., and later printed in "TV" magazine, April 1956, said, "If you take a look at the top 20 of the all-time grossing films you will find that 13 of them have been made since the competition of television. TV has actually been a boon . . ." He declared that the statistics could be interpreted as meaning only that some years had been better than others. "What we need to remember," he said, "is that movies are a basic entertainment medium even if they are an invention of the 20th century. Right along they've competed successfully with the innumerable other forms of leisure time activity. They've won over radio, mah jong, miniature golf . . . television is just the latest of a long line of enticements."

On the other hand, testimony from motion-picture producers who appeared before the Senate Small Business Subcommittee during a recent inquiry into trade practices blamed television as a major factor contributing to the motion-picture industry's present problems.

Abe Montague, Vice-President and General Sales Manager for Columbia Pictures, said that most of exhibition's problems stem from competition with TV and drive-in theaters. After explaining the detrimental effect of TV on the motion-picture industry, Montague made it plain that he bore no animosity for the television industry. He said: "Much as we may regret the dislocations and hardships which have resulted from them, I see nothing insidious in the rise and development of new entertainment media which have the acceptance and approval of the public."—*R.H.*

Obituary

Harry H. Strong, a Fellow of the Society and President of The Strong Electric Corporation, Toledo, Ohio, died on May 3, at the age of 69.

Mr. Strong, who was a well-known figure in the motion-picture projection and lighting industry, first achieved recognition when he invented and developed an automatic feed for carbon arc lamps in 1922. This control system simplified the job of the projectionist and made the arclamp a practical light source for motion-picture projection.

To manufacture and sell this control on a larger scale, Mr. Strong formed Strong Electric in 1923. Under his guidance the company underwent eight expansion programs since its founding and as the world's largest manufacturer of carbon arc lamps, today produces arc lighting for theaters, schools, television and the graphic arts industry as well as searchlights for the Navy, health arc lamps, slide projectors, theatrical spot lights and transformers. About 1930 Strong Electric was sold to General Precision Equipment Corp. of which it is now a subsidiary.

Mr. Strong joined the SMPTE in 1928 and became a Fellow in 1934. He served for five years—1948–1953 —on the 16 & 8mm Committee.

Always active in the theater equipment field, Mr. Strong was a charter member of the Theatre Equipment and Supply Manufacturers Association and a member of its Board until 1955.—*S.G.*

Membership Certificates (Active and Associate members only). Attractive hand-engrossed certificates, suitable for framing for display in offices or homes, may be obtained by writing to Society headquarters, at 55 West 42d St., New York 36, Price: $2.50.

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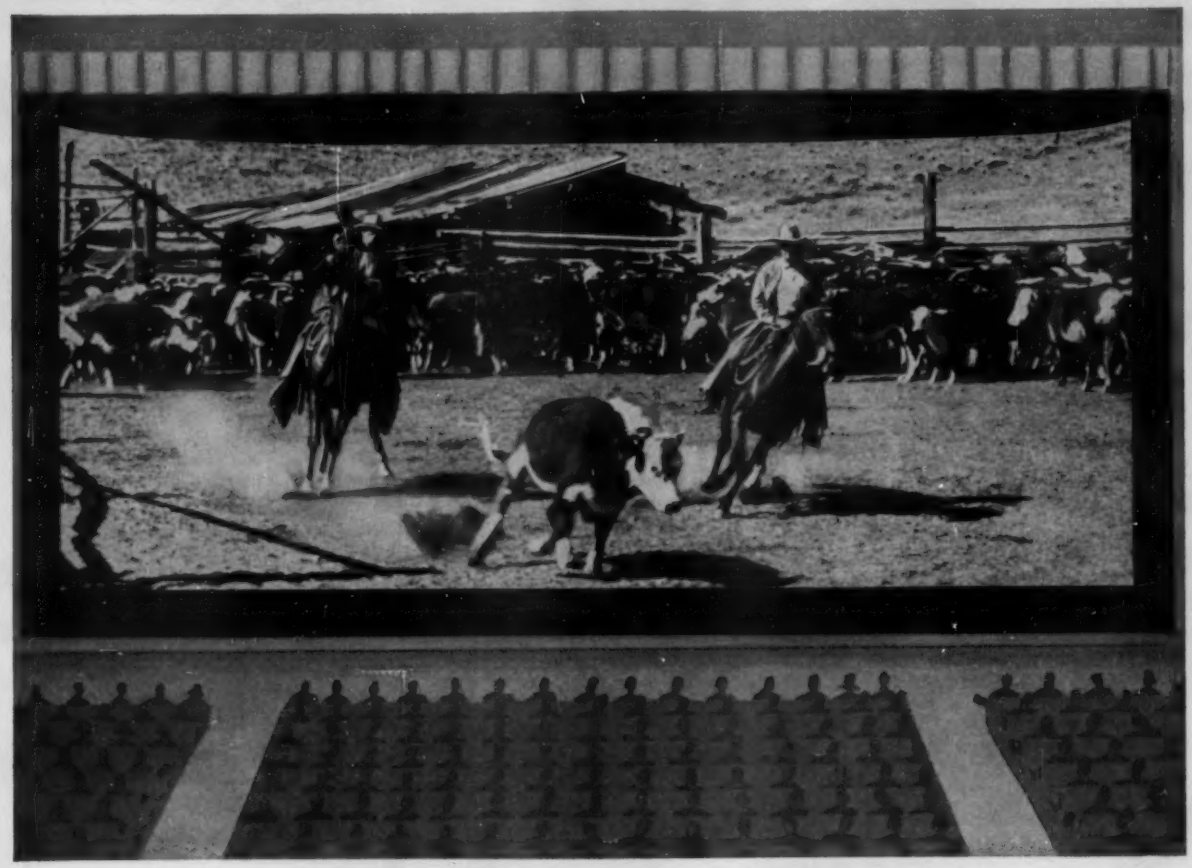

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THEATRE SOUND SYSTEMS

section reports

The Southeastern Section met on April 12 in the Architecture Auditorium of the Georgia Institute of Technology. The meeting was attended by 45 members and guests. Principal speaker was Hazard E. Reeves, President of Cinerama, Inc., who spoke on "The Cinerama System for Production and Exhibition of Motion Picture Films." He described the Cinerama system, giving details of the picture and sound processes involved, with amusing reminiscences of the development of Cinerama and its early difficulties.

E. M. Stifle, SMPTE Sections Vice-President reviewed the aims and activities of Society, extending an invitation to interested visitors to become members. A question-and-answer period was held at the conclusion of Mr. Reeves' address.—*Ivan Miles*, Secretary-Treasurer, c/o Radio Station WGST, Atlanta, Ga.

The Central Section met on May 21 at the Western Society of Engineers, Chicago, with an attendance of 40. Speakers were Hugh E. McLachlan, Supervisor of Projection, Y & E Theatre Circuit, and James L. Lahey, General Manager, Dare Television Div., Thompson Products.

Mr. McLachlan spoke on "Problems Associated With the Projection of Recently Released Motion-Picture Film Products." He centered his discussion on problems arising from the use of sources of high-intensity illumination in projectors, and explained that it has been found necessary to provide additional cooling at the aperture of the projectors to prevent buckling of film. He said that some out-of-focus problems had resulted from heat expansion of the projection lens, but that many field heat problems had been reduced to minimum by maintaining the projection rooms at a temperature of 80°F or below.

Mr. Lahey talked on "Putting the Vidicon and the Kinescope to Work Together," telling how and where closed circuit TV systems are aiding in education. He also described a fully integrated mobile TV unit consisting of a vidicon camera, tape recorder, kinescope recorder, slide and film projectors and rapid processor. He discussed the application of this equipment in the adult education program in Louisiana.—*H. H. Brauer*, Secretary-Treasurer, c/o Bell & Howell Co., 7100 McCormick Rd., Chicago 45.

The Pacific Coast Section met on May 22 at the American Broadcasting Co., Studio A, Hollywood, with an attendance of 250. The program was a well balanced TV and motion-picture presentation and was received with great interest. Speakers were Jay E. Gordon, Berry Scripts, LaMirada; William V. Stancil, Stancil-Hoffman Corp.; Dr. C. R. Daily, Paramount Pictures Corp.; and Benjamin Berg, Benjamin Berg Agency.

Mr. Gordon spoke on "Film and Origins of the Motion Picture." He presented a film made for the U.S. Navy and described its production. The film traced the development of the motion picture from its beginnings, featuring Edison's 1889 strip-kinetograph, the first motion-picture camera to use roll film. Mr. Stancil's topic was "A Printed Circuit Transitor Amplifier for Magnetic Recording and Reproduction Equipment." He discussed and demonstrated a magnetic recorder/reproducer using an automatic gain-control recording amplifier and employing printed circuitry and transistors. The reduction in size and increase in automatic features of the magnetic recorder/reproducer were of special interest to the group.

An interesting paper on "High Efficiency Rear-Projection Screens" was presented by Dr. Daily for the benefit of the members who had not attended the SMPTE convention at New York where the paper was first presented. Data were given on the transmission and reflectance characteristics of this new screen, together with data on several other experimental screens which have wide-angle and high transmission characteristics. Eastman Color Negative film can be used to photograph this new type of high-efficiency rear-projection screen with the camera operating at $f/4$ at 24 ft/sec.

In his paper on "Mobile Kinescope Recording Setup," Mr. Berg presented facts relating to the successful arrangement required in the use of a mobile kinescope recording truck for both 35mm and 16mm picture and sound recording. He discussed in detail some of the previous problems involved and conducted a tour of the truck where the equipment is installed.—*John*

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The motor is furnished with its own 110 volt, 60 cycle AC power supply. Output to the camera motor is 42 volts, 60 cycles AC and to the Torque Motor on the magazine (when used) 8 volts DC.

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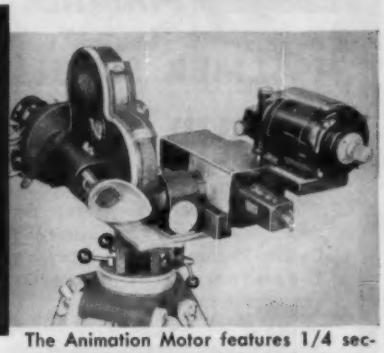

The Animation Motor features 1/4 second exposures for either single frame, or continuous shooting at 60 frames per minute. A built-on frame counter registers up to 4 digits.

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W. DuVall, Secretary-Treasurer, 4829 Cartwright Ave., N. Hollywood.

The Atlantic Coast Section met on June 4 at the Carl Fischer Concert Hall, New York. The speakers, William Briggs and Wallace Elton, both of the J. Walter Thompson Co., addressed an audience of 50 persons on advertising subjects. Mr. Briggs spoke on "Advertising and Selling, the People's Business," and Mr. Elton spoke on "How to Build a Working Advertisment." Both speakers discussed the techniques and procedures of present-day advertising with the aim of acquainting film producers with the special problems of advertising agencies.—*Victor M. Salter*, Secretary-Treasurer, % E. I. du Pont de Nemours & Co., Inc., 248 W. 18 St., New York.

High-Speed Photography Congress

A pamphlet containing the program of the **3d International Congress, on High-Speed Photography** is available in limited number at SMPTE headquarters, obtainable upon request to The Editor of the *Journal*. Or your can write to The Congress Secretariat, Department of Scientific and Industrial Research, Charles House, 5–11 Reagent St., London S.W.1.

This publication supplements the information contained in a pamphlet issued in February 1956. In addition to a program and time table, the brochure contains registration blanks to be filled out and returned to the Secretariat, complete information and instructions on transportation and accommodations, and a description of the various excursions which have been planned. A few changes in the time table may be made before final arrangements are completed. Transportation and accommodations are being handled by Thos. Cook & Son Ltd.

Announcements appeared earlier in the *Journal* in March (p. 174), April (p. 229), and May (p. 290).

New Concept of Universe — Problem for Physicists

By Earl Ubell

[For this nice exposé of man's ignorance of what can really be the matter of the universe we are indebted to the *New York Herald-Tribune* (for April 10, 1956) and its Science Editor, Earl Ubell, who is reporting from a meeting at Rochester, N.Y. The gravity in the situation is already acutely in the minds of our photographic instrumentationists. Our electronics engineers have long been seeking to cope more successfully with cosmic rays. Some recent earthly radiations are the constant preoccupation of those working with film emulsions. Perhaps way over the horizon in outer space lies the answer to the problem of storing in the air (no film; no tape) color television programs for delayed broadcast. Our own limited study to date indicates only that there may be a hostile atmosphere on Mars or Jupiter or some given nebula, that they might sabotage our programs with a wicked curve in the comeback.—*Ed.*]

Physicists, the men who study the nature of matter and energy, are entering a bold new era of discovery bent on finding order in the confusion before them.

At their sixth annual discussions at the University of Rochester many leaders in nuclear science gave the distinct impression that out of their puzzlement may come a new conception of the universe.

The physicists—200 of them, including three Russians—discussed the results yielded in the last few years from cosmic ray research and from their atom smashers. Cosmic rays are atomic showers from outer space.

Crashing atom upon atom, physicists are tickling the innermost nub of the atom, the nucleus, trying to identify the fundamental stuff of matter, trying to figure out what holds it together, and trying to see how its pieces fit together.

To get some idea of why confusion reigns, one must go back in the history of atomic research to about forty years ago when the atom was thought to be an extremely small mass of positive electricity in which little bits of negative electricity—electrons—were imbedded like raisins in a bun. The whole thing was believed to be only .000000000001 cm. wide.

Several years later it was proved that the atom really was composed of a dense central nucleus one thousand times smaller than the size of the atom with positive electricity. Negative electrons supposedly enveloped the nucleus like a fog.

In the next years, the nature of the fog was well elaborated: how it governed the chemical behavior of various elements; how the electrons were arranged in levels about the nucleus; how it was possible to predict the behavior of light striking the electronic fog.

But the nucleus itself remained a mystery until 1932 when Sir James Chadwick discovered the neutron, a lump of matter as heavy as the smallest atom of all, the hydrogen atom, but without electric charge. With this discovery the mystery deepened. Until then, it was believed that the nucleus was composed of hydrogen atoms sprinkled with electrons.

Physicists soon found that it was impossible for electrons to exist in the nucleus and that the core was really made up of neutrons and protons—another name for the core of the hydrogen atom. Now the puzzle was: "What held the core together?"

Protons were charged with positive electricity. By the old rule that similar charges repel each other, the protons should push away from each other causing the disintegration of any nucleus in which they were found. The neutrons couldn't help because they were without charge. Gravity was infinitely weaker than electric force and could not supply the necessary counterbalancing attraction.

In 1935, Dr. Hideki Yukawa suggested a way out. Suppose, he said there was another atomic particle about one-sixth the size of the proton or the neutron, which are about equal in size. Suppose this intermediate sub-atom, which was called the meson, was flung back and forth between proton and neutron in the nucleus. This

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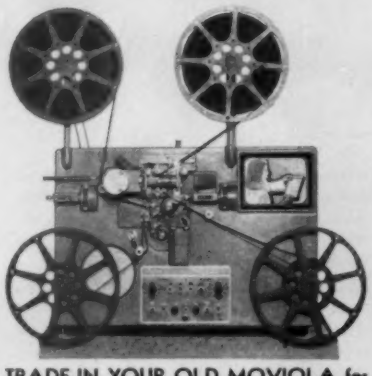

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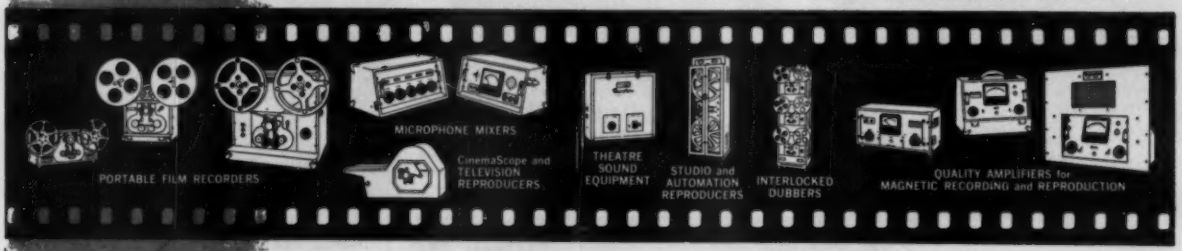

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CHICAGO—Zenith Cinema Service, Inc., 3252 Foster Ave., Chicago 25, Ill. IRving 8-2104.

SAN FRANCISCO—Brooks Camera Co., 45 Kearney St., San Francisco, Calif. EXbrook 2-7348.

CANADA—Alex L. Clark, Ltd., 3745 Bloor St., Toronto 18, Ontario. BEImont 1-3303.

should generate an attractive force between the two, he added. In 1937 the meson was discovered.

Within a few years many new measurements had been made on the meson provoking a strange new puzzle. The measurements did not fit any of the known theoretical mathematical models of matter.

On top of this problem the cosmic ray and atomic accelerator scientists began to discover more particles of different weights and electric charge. Now more than a score are known. Nobody has proposed an adequate theoretical scheme to account for them, predict new ones or discover how they might behave inside the nucleus. In the last year no new particles have been found; which led Dr. J. Robert Oppenheimer to remark at the conference, that scientists could be in possession of the ultimate atomic particle — but he was not sure.

In addition to the profusion of particles, it is now discovered that some of these particles have the weird property of seeming to be completely alike in every respect but behaving differently in the way they disintegrate and in the way they interact with other particles. For this the physicist is now forced to find new mathematical explanations.

There is a strong feeling among many of the theoretical physicists that some of their cherished principles like the conservation of energy or the constancy of the velocity of light may have to be sacrificed to make a new scheme for the new particles.

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The Television Society

The Television Society was founded in 1927 in Great Britain when a young Scotsman, J. L. Baird, appeared before the British Association for the Advancement of Science and demonstrated his invention of "seeing by wireless." A rather touching comment on pioneers in general and Baird in particular is given in a booklet about the Television Society. After describing the gradual development of television, it notes: "The year 1934 saw the start o high-definition television and the doom of mechanical scanning systems. J. L. Baird, who had his main interest in optical and mechanical studies, did not take kindly to the inevitable changes and retired to his private laboratory to experiment with colour and stereoscopic television."

Baird's first public appearance to show his invention had been before the Royal Institution in January 1926. A year later, after he had developed a new method of scanning an image by means of infrared radiation, he was invited to appear before the British Association. With his assistant, J. J. Denton, he gave daily demonstrations of what he termed "Noctovision" and television. Interest in the new invention was immediate, and approximately 50 enthusiasts formed the nucleus of what was to become the Television Society that now claims over 1000 members.

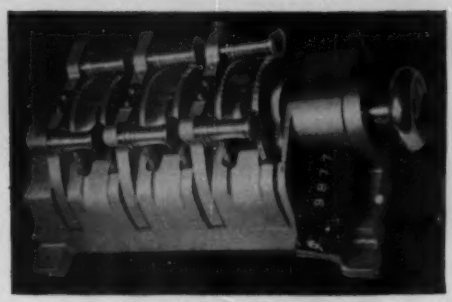
By 1928 the first regular transmissions were being sent out from the Baird Company's station "2TV" at Long Acre. They were of a 30-line picture repeated 12½ times per second, with vertical scanning. This standard persisted until the closing of the BBC studio in Portland Place from which the signals were transmitted to Brookman's Park. In 1930, BBC took over the transmission of television and a program was broadcast for half an hour each night, vision on 261 meters and sound on 365 meters.

The cathode-ray tube, as a means of reproducing television pictures, had been the subject of experiment by von Ardenne, Baird and others as early as 1929, and in 1931 the first symposium on cathode-ray television was held by the Society at University College. By 1934 the trend of the Television Society had begun to alter. From a group of enthusiastic amateurs, the Society gradually came to attract persons who were making a career of television. It is now a specialist society, appealing primarily to professionals, although it accepts applications from all interested in television. Its interests are limited to the furthering of television, as distinct from the entire field of radio communication.

The Television Society is a nonprofit organization which performs the expected functions of holding meetings, dispensing information in its *Journal* and by a monthly news bulletin to its members. Its quarterly *Journal* has many worthy articles such as these recent ones: "An Industrial Television Channel," "An Unconventional Wired Television Distribution System," "Operating Experiences with the BBC Television Studios at Lime Grove" and "Experimental Colour Television."

The Society's *Journal* is now in its eighth volume, seven volumes of three years each having already been published and being

SYNCHRONIZER HEAVEN



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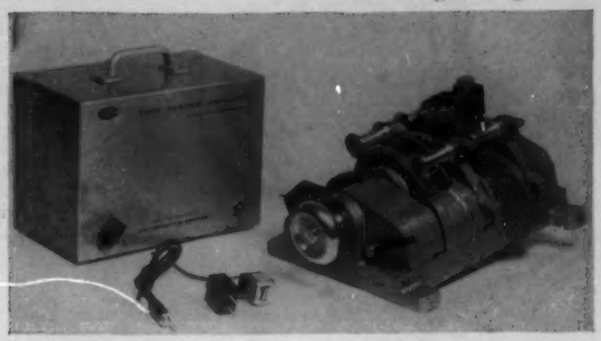

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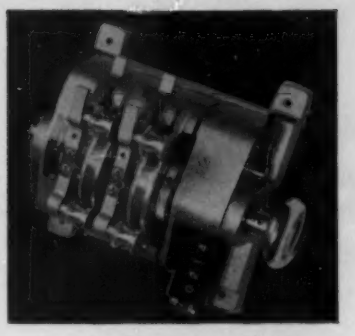

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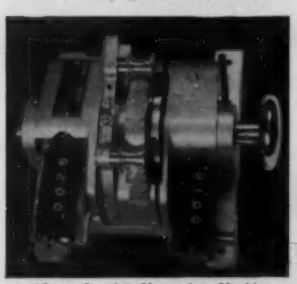

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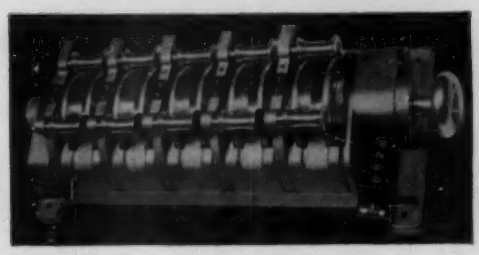
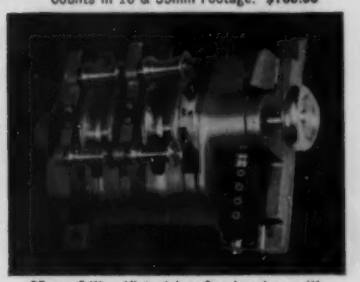


35mm 5-Way Synchronizer $225.00



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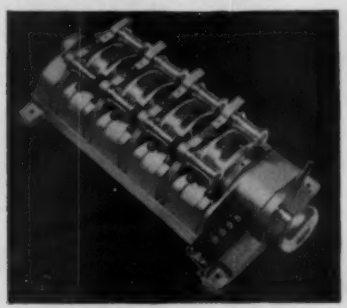
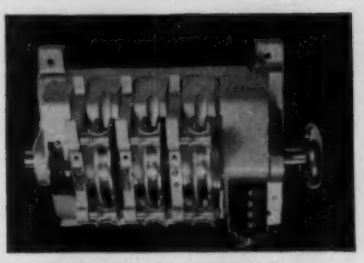


35mm 4-Way Synchronizer $190.00



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to a considerable extent available as back issues. Information about the Television Society's requirements for membership and about subscriptions to its *Journal* is available from the Society's present headquarters, 164 Shaftesbury Ave., London W.C.2. — R.H.

New Members

The following members have been added to the Society's rolls since those last published. The designations of grades are the same as those used in the 1956 MEMBERSHIP DIRECTORY.

Active (M) Associate (A) Student (S)

This is the third list of New Members supplementing the April Journal, Part II, Directory.

Axtmann, Horst, Manager & Chief Ed., Film-Echo-Weisbaden, Taunusstr 75, Weisbaden, W. Germany. (M)

Baldwin, Myron Burch, Manager, Camera Dept., Beckman & Whitley, Inc.: 985 San Carlos Ave., San Carlos, Calif. (M)

Barth, Gerson, West Coast Mgr., Ansco. Mail: 2027 N. Serrano Ave., Los Angeles. (A)

Bason, Kenneth Harold, Projectionist, Prudential Theatres. Mail: Union Ave., Holbrook, N.Y. (A)

Blake, Robert C., TV Eng., KOSA-TV. Mail: 215 W. 17, Odessa, Tex. (A)

Bleckman, Morris, Photo., Cinema Processors. Mail: 5542 S. Ada St., Chicago. (A)

Brown, Harold R., TV Eng., ABC. Mail: 464 C St., Colma, Calif. (A)

Buist, John Alex, Sales Mgr., Minnesota Mining & Mfg. Co. of Can., Oxford St., E., London, Ont., Can. (A)

Burritt, Oscar Chamberlin, TV Film Consultant, CBC. Mail: 130 Carlton St., Toronto, Ont., Can. (M)

Caldarone, Caesar J., Photo Dealer, 92 Highland Dr., Waterbury, Conn. (A)

Caldwell, William H., Projectionist, WS Butterfield Mich. Theatres, 58 North West, Hillsdale, Mich. (A)

Carriker, Ronald Charley, Univ. of Miami. Mail: 447 Brent St., Winston-Salem, N.C. (S)

Carter, Perry L., Projectionist, Mot.-Pic. Operators Union Local 160. Mail: 3719 Ingleside, Cleveland. (A)

Cavolo, Don, Projectionist, Loew's Stillman. Mail: 2275 Murray Hill Rd., Cleveland. (A)

Clarke, Frederick Lindgren, Industrial Eng., Pathé Labs., Inc. Mail: 950 Dana Ave., Valley Stream, N.Y. (M)

Coleman, Kenneth J., Sales Mgr., Consolidated Film Ind. Mail: 395 Chestnut, Paramus, N.J. (M)

Conley, Carl E., Tech Photo., North American Aviation. Mail: 2637 W. Caldwell St., Compton, Calif. (A)

Coons, Maynard A., Mot.-Pic. Specialist, General Electric Co., 2900 Campbell Ave., Schenectady, N.Y. (A)

Cooper, Leonard, Attorney, DuArt Film Labs. Mail: 3770 Dianne St., Bethpage, N.Y. (M)

Dallwig, George Arthur, Cinematographer, Northrop Aircraft. Mail: 8005 Rothdell Trail, Hollywood 46. (A)

Day, George D., Field Engineer, General Electric Co. Mail: 416 Molimo Dr., San Francisco 27. (A)

DeRosa, Patsy, Film Editor, Telenews Film Corp. Mail: 6408 16 Ave., Brooklyn, N.Y. (M)

Deubel, William, Projectionist, Mall Theatre. Mail: 4548 Ranchview, Cleveland. (A)

Donaldson, Edward, Projectionist, Loew's Stillman. Mail: 33790 Wooster Rd., Rocky River, Ohio. (A)

Edwards, Lewis Morgan, Projectionist, RKO. Mail: 226 Elmore Ave., Trenton, N.J. (A)

Einfeld, Richard, Vice Pres. Production, National Picture Corp. Mail: 3310 Mandeville Canyon Rd., Los Angeles 49, (M)

Endelman, Lincoln L., Research Asst., Case Institute of Technology, 10900 Euclid Ave., Cleveland 6. (A)

Ettenson, David Herbert, Mot.-Pic. Photo., Free-Lance, 110-56 71 Ave., Forest Hills, N.Y. (M)

Evraets, Vernon John, Mech. Eng., Mitchell Camera Corp. Mail: 1336 Allen Ave., Glendale, Calif. (A)

Fanoe, Lauge S., Chief Elec. Eng., J. A. Maurer, Inc., 37-01 31 St., Long Island City, N.Y. (M)

Feil, Edward R., Film Producer, Free-Lance, 2343 Ardleigh Rd., Cleveland 6. (A)

Fellers, Raymond D., Lab. Sales, DuArt Film Labs., Inc., 245 W. 55 St., New York 19. (M)

Fernandez, Richard J., TV Eng. KGO-TV, ABC. Mail: 281 Green St., San Francisco.

Fortenbaugh, David Edgar, Sch. Radio Tech. Mail: 167 West End Ave., Newark 6, N.J. (S)

Gibbs, William Richards, Agency Film Producer, Young & Rubicam, Inc., 285 Madison Ave., New York. (A)

Ginsburg, Charles Pauson, Chief Eng., Ampex Corp. Mail: 640 Orange Ave., Los Altos, Calif. (M)

Gizowsky, Joseph, Mot.-Pic. Eng., U.S. Army Signal Corp., Pict. Center. Mail: 124 Kensington Rd., S., West Hempstead, N.Y. (M)

Grummisch, Lorne H., Photo., National Research Council Can. Mail: 184 McArthur Ave., Ottawa 2, Ont., Can. A. (A)

Hall, Howard J., Rochester Inst. Tech. Mail: 148 Troup St., Rochester 8, N.Y. (S)

Hall, John W., Broadcast Eng., ABC. Mail: 244 Sequoia Ave., S. San Francisco. (A)

Hancock, James Barton, Chief Eng., McClatchy Broadcasting Co. Mail: 12 Fedora, Fresno, Calif. (M)

Haney, Edward H., Projectionist, Shaker Theatre, Mail: 15308 Benhoff Dr., Maple Heights, Ohio. (A)

Hayes, Thomas Newell, Univ. Miami. Mail: 438 Minorca, Coral Gables, Fla. (S)

Heimberger, Paul W., Photo., Colind Photo., 713 Main St., Peoria, Ill. (M)

Horstkorta, Donald A., TV Eng., KGO-TV, ABC. Mail: 1046 Ringwood Ave., Menlo Park, Calif. (A)

Hudson, William Christoff, Cambridge Sch. Radio & TV. Mail: 1071 Bergen St., Brooklyn 16, N.Y. (S)

Jasiukonis, Paul, Univ. So. Calif. Mail: 1730 S. Hobart Blvd., Los Angeles 6. (S)

Johns, Sydney Gene, Univ. Miami. Mail: Box 642, Evansville, Ind. (S)

Kelley, Fred Clayton, Projectionist, Villa Theatre. Mail: 7905 Flower Ave., Apt. 2, Takoma Park, Md. (A)

Kellock, James A., Vice-Pres. Operations, Wilding Picture Productions, Inc., 1345 Argyle St., Chicago 40. (M)

Kjeldsen, Holger Carl, Film Ed., Byron, Inc. Mail: 12509 Feldon St., Silver Spring, Md. (A)

Koppel, Walter, Managing Dir., Real Film Studios. Mail: Schoene Aussicht 12, Hamburg, W. Germany. (M)

Korb, Leo I., Projectionist, Colony Theatre. Mail: 5415 Summit, Lyndhurst, Ohio. (A)

Lee, Harry, Projectionist, Loew's Stillman. Mail: 16904 Fisher Rd., Cleveland. (A)

Leslie, John M., Jr., Chief Audio Eng., Ampex Corp. Mail: 2645 Ramona St., Palo Alto, Calif. (M)

McCaslin, Robert C., Sales Promotion, Caterpillar Tractor Co. Mail: 815 Finney St., Chillicothe, Ill. (A)

Madson, Max Tanner, Mot.-Pic. Sound Eng., Office of Info. Dept. of Agri. Mail: 2-A Southway, Greenbelt, Md. (A)

Mitchell, John Donald, Design Eng., Eastman Kodak Co., Apparatus & Optical Div., 400 Plymouth Ave., Rochester 9, N.Y. (M)

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Moore, Howard S., Film Cutter, Free-Lance. Mail: 6930 Nestle Ave., Reseda, Calif. (A)

Mowbray, Coates S., Office Mgr., DuPont de Nemours & Co., 1628 Oaklawn, Dallas, Tex. (A)

Nell, Edward, Jr., Mot.-Pic. Producer, U.S. Navy Photo. Center. Mail: 2100 N. Pierce St., Arlington, Va. (A)

Norling, Richard Victor, Cameraman, Byron Motion Pictures. Mail: 12119 Edgemont St., Silver Spring, Md. (A)

Olevsky, Benjamin, Projectionist, Radio City Music Hall. Mail: 945 E. 94 St., Brooklyn 36, N.Y. (M)

O'Rork, Charles Ternan, Jr., Cameraman, Free-Lance. Mail: 1345 Hardy St., Orlando, Fla. (M)

Perrin, Douglas Lloyd, Adv. Copywriter, BBDO Advertising Agency, 120 Montgomery, San Francisco. (A)

Pico, Alfonso Suro, Chemist, Byron, Inc. Mail: 3605 Brothers Pl., S.E., Washington 20, D.C. (A)

Pohl, Wadsworth E., Eng., Technicolor, 6311 Romaine, Los Angeles. (M)

Post, Dudley K., Cinemat., Free-Lance, 217 Edwards Dr., Fayetteville, N.Y. (A)

Quinn, Findlay J., Asst. Supt., National Film Board, 3355 Cotis De Liesse, Montreal, P.Q., Can. (A)

Richie, John P., Projectionist, 1628 Cohassett, Cleveland. (A)

Rittgers, Albert Jackson, Cambridge Sch. Radio & TV. Mail: 288 Boulevard, New Milford, N.J. (S)

Roach, Richard J., TV Studio Eng., ABC. Mail: 94 Rockaway Ave., San Francisco 27. (A)

Robertson, John L., Jr., Sales Mgr., Bell & Howell Co., 742 Wyatt Bldg., Washington, D.C. (M)

Rosenfeld, Max H., Projectionist, Mall Theatre. Mail: 12606 Edmonton, Cleveland. (A)

Rusten, Paul Daniel, Mot.-Pic. Producer, Continental Films, 47 S. Ninth, Minneapolis 26, Minn. (M)

Ryan, John Leo, TV Eng., ABC. Mail: 793 Alta Loma Dr., S. San Francisco. (A)

Sanguinetti, Paul G., TV Eng., KGO-TV & Consulting. Mail: 1207 Fifth Ave., San Francisco. (A)

Saraceni, Dante A., Audio Eng., Gray-O'Reilly Mot.-Pic. Studios. Mail: R.F.D. #5, Bankside Dr., Huntington, N.Y. (M)

Scott, William E., Electronics Eng., The Rand Corp., 1700 Main St., Santa Monica, Calif. (A)

Seaman, James H., Jr., Cameraman, Manhattan Film Service, Inc., 45 W. 45 St., New York 36. (M)

Seiler, Robert, Univ. Penn. Mail: Star Route, Rector, Pa. (S)

Sheridan, Richard, Projectionist, Embassy Theatre. Mail: 2219 Broadview Rd., Cleveland. (A)

Siegel, Ron George, Univ. Miami. Mail: 2313 S.W. 10 St., Miami, Fla. (S)

Shekell, Lennox L., Univ. So. Calif. Mail: 963½ N. Serrano Ave., Los Angeles 29. (S)

Slee, Warren A., Univ. So. Calif. Mail: 10628 Cushdon Ave., Los Angeles 64. (S)

Smith, Paul H., Dist. Sales Mgr. Mail: Du Pont Photo Products Dept., 1628 Oaklawn, Dallas, Tex. (A)

Smith, Warren George, TV Eng., Harwatts, Inc., 361 12 St., Cresskill, N.J.

Snyder, Paul Chapman, Jr., Mot.-Pic. Writer-Dir., North American Aviation, Inc., 12214 Lakewood Blvd., Downey, Calif. (A)

Somach, Norman, Columbia Univ. Mail: 529 W. 111 St., New York. (S)

Stuven, Luis Marcos, Recording Eng., Electrical & Musical Ind., Casilla 186-D, Santiago, Chile. (A)

Valle, Joe A., Jr., Army Pict. Center, 35–11 35 Ave., Long Island City 1, N.Y. (S)

Vassilopulos, John Constantino, Centro Sperimentale di Cinemato. Via Tuscolana 1094 Cinecitta, Rome, Italy. (S)

Weiss, Arnold, Mot.-Pic. Projectionist, Cedar-Lee Theatre. Mail: 2540 Channing Rd., University Heights 18, Ohio. (A)

White, Andrew James, Research Eng., Motor Vehicle Research, Inc., Newmarket R.F.D., S. Lee, N.J. (M)

Whitehead, Jack, Dir. of Photo., Fred A. Niles Productions, Inc., 22 W. Hubbard, Chicago. (M)

Willard, Frank H., Jr., Film Producer, Free-Lance. Mail: 3223-B Cain's Hill Pl., NW, Atlanta, Ga. (M)

Wurzer, George, Production Mgr., Westrex Corp. Mail: 33–40 28 St., Astoria 6, N.Y. (A)

Ziegenfus, Elmer F., Pres., Fotomart, Inc., 8 S. Sixth St., Philadelphia 6. (A)

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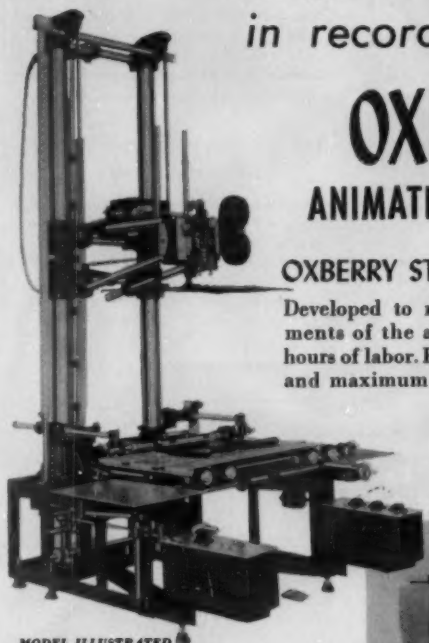

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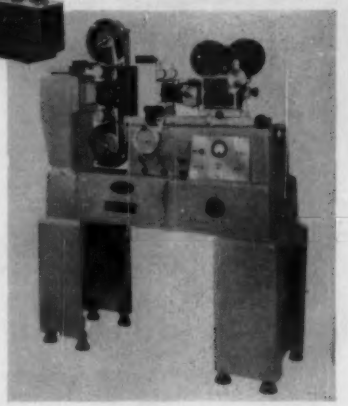

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current literature

The Editors present for convenient reference a list of articles dealing with subjects cognate to motion-picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D.C., or from the New York Public Library, New York, N.Y., at prevailing rates.

American Cinematographer vol. 37, Apr. 1956

New Accessories Extend Range of 16mm Arriflex (p. 226)

Byron Opens New Negative-positive Processing Lab (p. 242)

Aspherics Promise Faster Cine Lenses (p. 246)

vol. 37, May 1956

Mobile Camera Shots for "The Fastest Gun Alive" (p. 294) *G. Folsey*

Plastic Blimps for Shooting Movies Under Water (p. 297) *R. Little*

Closed-Circuit Print Inspection Aid to TV Film Photography (p. 299) *P. Tannura*

Wide Angle Problems in Wide Screen Photography (p. 300) *G. Rescher*

The New Oxberry Combination 35mm/16mm Process Camera (p. 302) *V. W. Palen*

Bell and Howell Introduces First Automatic Movie Camera (p. 310) *J. Forbes*

British Kinematography vol. 28, Mar. 1956

"How" Not "Where" (p. 74) *H. S. Hind*

vol. 28, Apr. 1956

Notes on the Symposium on "Adapting Wide Screen Techniques to 16mm Film" Part I: Screens: Past, Present and Future (p. 113) *J. Prendergast*

Polyester Photographic Film Base (p. 120) *D. R. White, C. J. Gass, E. Meschter* and *W. R. Holm*

vol. 28, May 1956

A Survey of the Progress of Magnetic Recording (p. 156) *H. V. King* and *A. W. Lumkin*

Maintenance of Magnetic Recording and Reproducing Equipment. Part II (p. 159) *A. W. Lumkin*

Standards of Procedure for the Preparation of 16mm Printing Leaders (p. 170)

Electrical Engineering vol. 75, June 1956

Live Flying-Spot Color Scanner (p. 528) *J. H. Haines* and *G. R. Tingley*

Electronics vol. 29, June 1956

Television Receiver Uses One-Gun Color CRT (p. 150)

International Photographer vol. 28, Apr. 1956

"The King and I" (p. 4) *Milton Gold*

vol. 28, June 1956

Two New Wide Screen Processes (p. 8) *Walter Greene*

International Projectionist vol. 31, Apr. 1956

"More Light for Drive-In Screens" (p. 7) *R. A. Mitchell*

"How to Get More Out of Your Arclamp" (p. 14) *A. J. Hatch*

"Projection and Sound Requirements of the Drive-In Theatre" (p. 16) *B. Passman*

"Drive-In Projection Lenses" (p. 22) *J. A. Fetherston*

"Painting the Drive-In Screen" (p. 24) *L. Satz*

"Reverse CinemaScope Lens for Drive-ins" (p. 26) *B. Deneen*

vol. 31, May 1956

Evaluating Film Base Materials (p. 7) *R. A. Mitchell*

Technicolor Improves Color Printing Process (p. 14)

Kinematograph Weekly vol. 469, May 3, 1956

Sixty Years of Techniques (p. 69) *R. H. Cricks*

Early Days of Sound (p. 75) *T. T. Baker*

vol. 469, May 10, 1956

Europe's Most Modern Laboratory (p. xi) *R. H. Cricks*

Kino-Technik vol. 10, Apr. 1956

Schmalfilm in der wissenschaftlichen Kinematographie (p. 120) *J. Rieck*

Einsatz des Schmalfilms für ethnologische Forschungen (p. 123) *D. Spannaus*

Schmalfilmpraxis in Geographie und Völkerkunde (p. 126) *W. Haupt*

Technische Forderungen an das Schul-Schmalfilmgerät (p. 132) *H. G. Rescher*

Mikro- und Makro-Filmaufnahmen mit Bolex H-16 (p. 136)

Produktionssteigerung durch filmische Arbeitsanalyse (p. 140) *P. F. Fornallaz*

Telefunken-Magnetbandgerät für Schmalfilmvertonung (p. 142)

Entwicklung von Adox 16mm-Film N 17 in Kodak D 76 (p. 144)

Das Auftragen der Magnetspur auf Schmal- und Kinefilm (p. 146) *F. Biedermann*

Ein Verstärkersystem nach dem Bausteinprinzip: Zeiss Ikon Dominar Variant (p. 150)

30 bis 10000 Hz auf 16mm-Lichttonfilm mit der Maurer-Kamera (p. 154) *H. J. Janocha*

vol. 10, May 1956

Tonfilm-Aufnahme und Bearbeitung bei den Fernsehrundfunk-Sendestationen (p. 168) *W. Jahn*

Die Technik der Filmaufzeichnung vom Bildschirm (p. 174) *E. v. Gregor*

Magnetocord-Anlagen für die Fernsehfilmherstellung (p. 179) *A. Lohmann*

Die Übertragung von Filmen im Fernseh-Sendebetreib (p. 183) *v. Felgel-Farnholz*

Neue Geräte und Beleuchtungsanlagen für das Fernsehen (p. 186)

Drahtlose Pilotton-Anlage für Reportageaufnahmen (p. 188) *A. Klemt*

Neuer Lichttonverstärker für das deutsche Fernsehen (p. 189) *O. Diciol*

Transportables Magnettongerät für perforierten Film (p. 192) *H. J. Janocha*

Bibliography of Engineering Abstracting Services has been compiled by the Committee on Engineering Abstracting Services, Engineering Sec., Science-Technology Div., Special Libraries Assn., and edited by Miriam M. Landuyt, Research Librarian of the Caterpillar Tractor Co. This bibliography will give many new leads for helps in research — even though some of us will be puzzled about photography until we find the heading "Instrumentation and Photography." While we are interested to see many services well described, we hope that the only omission is that of Ansco Abstracts which are now in their 16th Volume. A name and title index makes delving into the 16 area headings a simple and efficient operation. The Bibliography is available at $1.50 a copy from the Special Libraries Assn., 31 E. Tenth St., New York 3.

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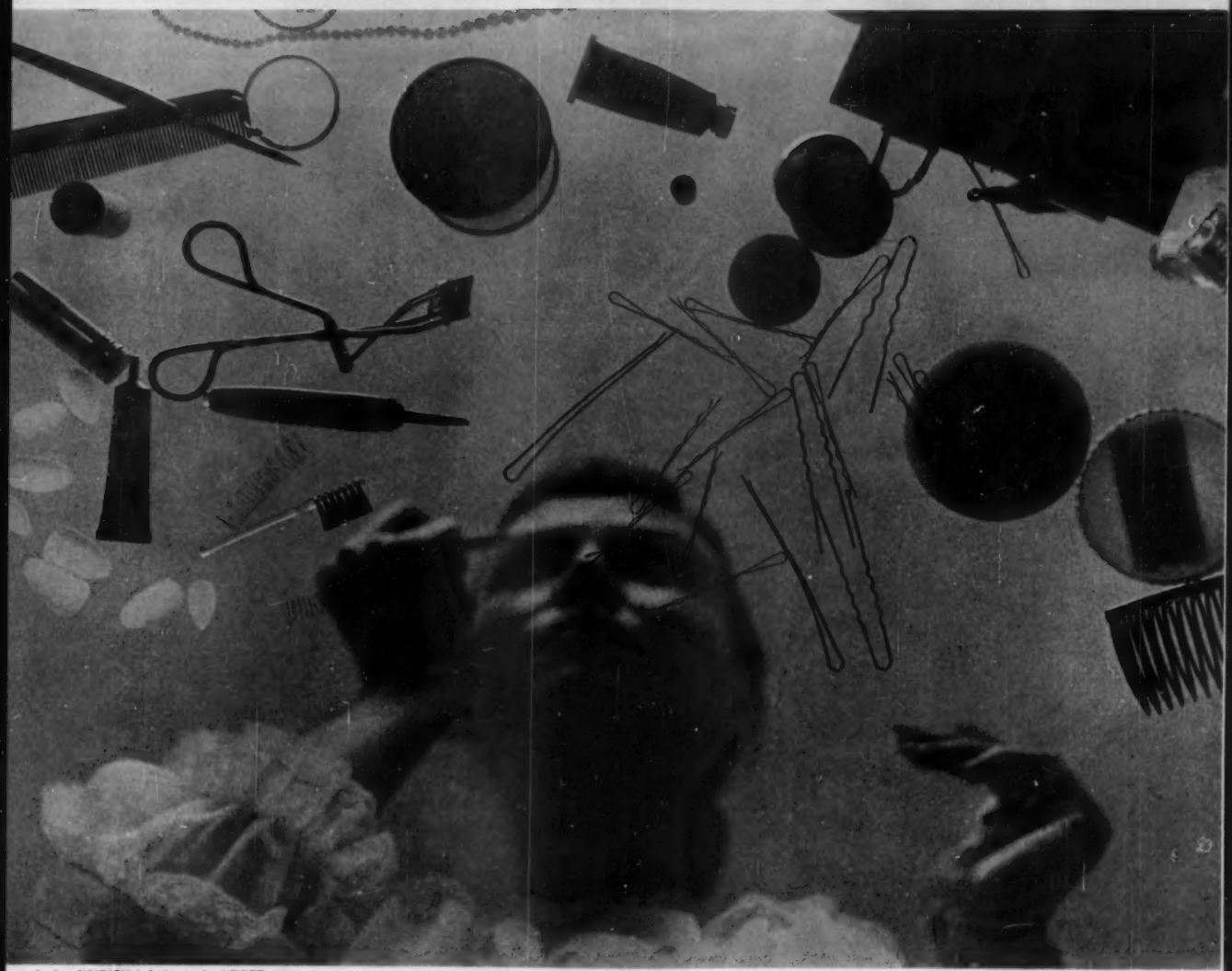

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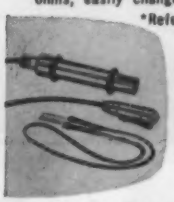

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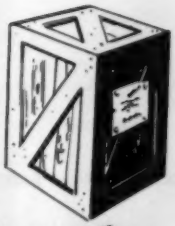


new products

(and developments)

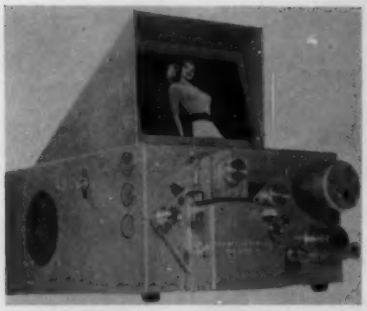
Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products or services.

A robot that can function as a motion-picture projectionist has been introduced by G.B.-Kalee Ltd., Mortimer House, 37–41 Mortimer St., London W.1. Called the Projectomatic System, "it" has reportedly been successfully used at a motion-picture performance in Great Britain. The machines switched on the lights, opened the curtains and regulated the sound. The human projectionist had nothing to do but mark the film, load it onto the projector and set the unit. The sequence in which the various operations are carried out is determined by the arrangement of pins set in a rotating drum or in the case of changeover operation by marks on the film. Once the drum has been set up and the film marked, the show will run continuously without further action by the operator other than to clean and lace the projectors, renew carbons and change discs.

The equipment consists of a main control cabinet and a number of relay units which are operated by signals received from the main control unit, and which in turn control the various switching functions on the projection equipment. In addition, special rollers are fitted on the projectors to detect the film marks and to operate an emergency stop circuit in the event of a film break or mechanical failure.

A new developing agent known as Phenidone, is manufactured by Ilford Ltd., Ilford, Essex, Eng. It is used in place of metol as an activating agent for hydroquinone with the resulting developer reported as having a lower rate of exhaustion than that of comparable M.Q. developers and better keeping properties.

Bell Telephone Laboratories has announced that it has developed thermistor materials that have large positive temperature coefficients. One material has a positive temperature coefficient from about −50 C to 110 C, with the coefficient reaching a value as high as 9%/°C. Another material of slightly different composition was found to have a positive temperature coefficient from about 50 C to 225 C with a maximum coefficient of 14%/°C. These materials in general consist of barium titanate or barium-strontium titanates to which small amounts of lanthanum have been added.



A new Professional 16mm Viewer has been introduced by Camera Equipment Co., 315 W. 43 St., New York 36. The viewer has been designed especially for professional use by use of a large picture size. It operates left to right, and has been designed to give a well illuminated picture and not to scratch the film. A frame and footage counter and a sound reader are available as accessories.

The General Precision Laboratory ii-TV or institutional and industrial closed-circuit system, is now serving in the training of advanced students in the Nebraska Psychiatric Institute at Omaha. The Institute's use of closed-circuit television enables the student to observe actual psychiatric treatment of even the most difficult cases without disturbing doctor or patient and therefore is expected to speed up the training period now required to graduate qualified psychiatrists.

Three cameras are used, each mounted with its control cabinet and monitor in a small cart, providing three completely mobile pickup units. The equipment is compact, the camera measuring 9 × 5½ in. and weighing 5 lb. The cameras are set up to cover three treatment rooms. The sound is picked up by microphones permanently installed in the ceiling of each treatment room. At the control room, the three pictures are monitored and the treatment selected for transmission to the auditorium. The entire operation of the system is carried on by Institute staff members.

Anticipating a wider use of the system, GPL has arranged with the Altec Service Corp. of New York to provide a nationwide, franchised maintenance service for its industrial television equipment.

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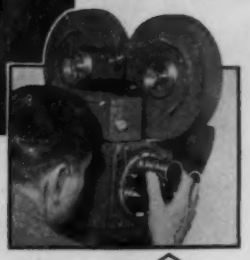

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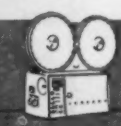

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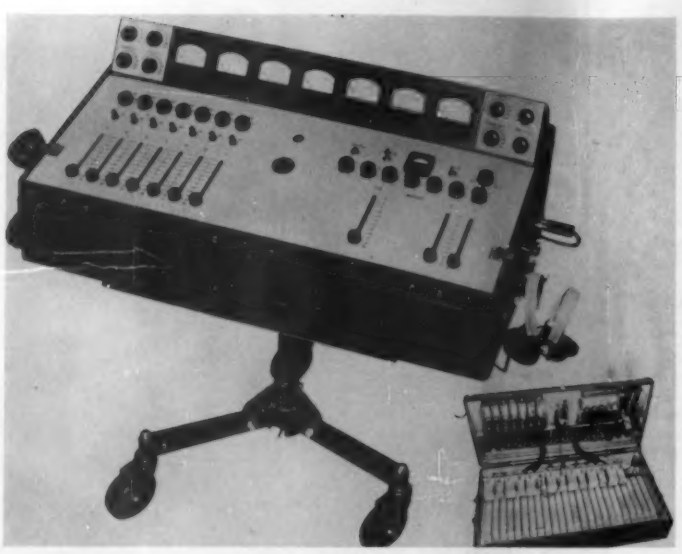

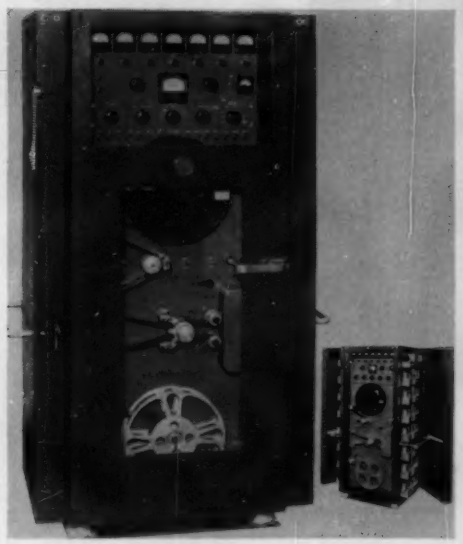

A completely transistorized multichannel mixer for motion-picture sound recording has been introduced by RCA. It is a 7-channel portable unit (MI-10121) containing 23 amplifiers and one oscillator. In addition, the unit accommodates filters, slide wire attenuators, and filter controls. It is claimed to use 25-times less power than would be needed for similar tube-type equipment. The case measures 34 × 17 × 7½ in.

Another recent RCA development is a 7-channel magnetic recorder (MI-29529), which operates at film speeds of 146.25 or 90 ft/min. It is especially designed for all motion-picture techniques using up to 7 separate tracks. The recorder is reported available for operation at any of the speeds employed by the industry. Seven magnetic playback amplifiers and main recording amplifier are mounted on specially designed shelves at the right of the recorder rack, as shown in the inset at right in the illustration. Bias oscillator and amplifiers are similarly installed on the left of the rack.

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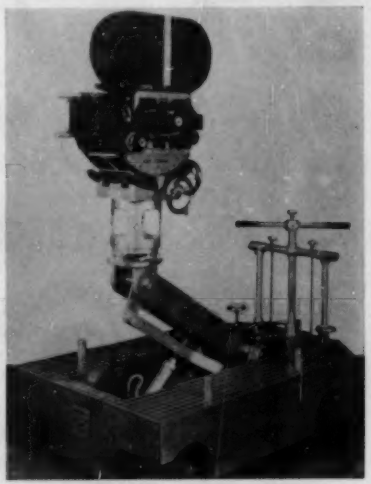
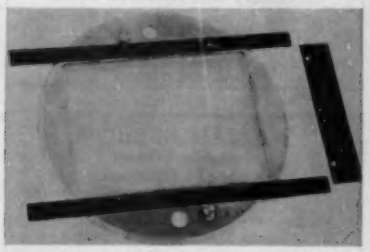


The Crab-Hydrolly is manufactured by National Cine Equipment, Inc., 209 W. 48 St., New York 36. Cast aluminum is used in the construction of the chassis and the camera boom arm. An adjustable vertical leveling arm holds the camera level in all positions. The dolly has dual wheels for both crab and conventional steering. A hi-hat is provided that gives added height to a maximum of 56 in. Without the hi-hat the maximum height to the top of the mounting head is 48 in., and the minimum height, 21 in. The dolly weighs approximately 750 lb.

A new Model 649 Miniature Lavalier Dynamic Microphone is announced by Electro-Voice, Inc., Buchanan, Mich. Designed for TV, the microphone measures 2$\frac{11}{16}$ × $\frac{3}{4}$ in. It is omnidirectional and can be hung on a neck cord to free the hands of the announcer or performer. Alnico V and Armco magnetic iron are used in its construction in a nonwelded circuit. Frequency response is reported uniform from 70 to 13,000 cycles/sec.

A tiny TV camera that measure $1\frac{3}{4} \times 2 \times 5$ in. has been developed by Lockheed Aircraft Corp., Burbank, Calif. It weighs $1\frac{1}{2}$ lb with 8mm film attached. It was designed especially for use in testing new aircraft both in flight and on the ground and can operate in temperatures up to 180°. This miniature camera makes it possible for research and flight test engineers to observe tests that otherwise could not be watched safely. Development of the camera took two years of work by Lockheed's electronic scientists. The aim was to produce a miniature camera rugged enough to withstand extremes of heat and cold and other forces present in flight testing.



The Animation Equipment Corp., 38 Hudson St., New Rochelle, N. Y. has announced a new line of Oxberry registration devices, designed specifically for animated film production. There are 11 units in the group, including two 22 in. × 17 in. planning cel tables, 3 drawing boards, 2 punches, and various peg bars and pegs. Type 92 drawing board is a $17\frac{3}{16}$-in. diameter aluminum disc with a glass center. When mounted on a drawing table, a $16\frac{1}{2}$-in. diameter hole is cut in the table to permit lighting from below. There are 2 moving peg bars with locks, one above and one below the field. Two sets of Oxberry standard pegs or pegs of customer selection are furnished. Moving peg bars permit this unit to be used as a limited planning board.

A new 11mm high-intensity positive projector carbon has been announced by National Carbon Co., 30 E. 42 St., New York 17. Designed to produce about 10% more light than other carbons operated at the same current, the 11mm × 20 in. projector carbon is recommended for operation in the 110- to 120-amp range. The new carbon is claimed to have greater durability, lasting from 20 to 25% longer than other carbons operated at the same current.

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Motion Picture and Still Photographer. College graduate, B.S. biology. Experienced medical photographer, all phases black-and-white, color scientific photo., with knowledge and use of various cine and still equipment. Varied freelance assignments. Attending City Coll. N. Y. Film Institute. Desires position with organization in metropolitan New York. George L. Wasser, 1845 Phelan Place, New York 53.

Positions Available

Equipment Sales Representative for inside and outside sales and rentals of professional motion-picture and audio-visual equipment. Thorough experience and knowledge of equipment necessary, must have good sales personality. Write resume, references and salary requirements. Florman & Babb, 68 West 45 St., New York 36.

Equipment Maintenance Man, with thorough experience in Moviolas, amplifiers, projectors, electrical equipment. Write experience, references, salary requirements. Florman & Babb, 68 West 45 St., New York 36.

Audio Engineer. Immediate opening in expanding engineering dept. for man experienced in audio work. Chances for advancement. Complete employee benefits. Please mail details to Personnel Director, Gates Radio Co., Quincy, Ill.

Electronic Engineers. Immediate openings in expanding engineering department for men with experience in fields of TV transmitter and studio equipment, communication transmitters and AM and FM transmitters. Permanent positions, chances for advancement, complete employee benefits. Mail complete details to Personnel Director, Gates Radio Co., Quincy, Ill.

16mm Laboratory Technician for expanding Florida laboratory. Opportunity for supervisor. Must be experienced in maintenance, chemicals, control, processing of black-and-white motion pictures. Color processing experience desired. Write full resume, references and salary requirements to P. O. Box 6474, Jacksonville 5, Fla.

Engineer with knowledge design and installation of film developing machines, control equipment, etc., to act as consultant. Part time initially. Write or phone Paul Klingenstein, President, Kling Photo Corp., 257 Fourth Ave., New York 10, SP 7-3200; representing Arnold & Richter K.G., West Germany.

Sales Engineer, top grade, needed to contact motion-picture studios, labs and government agencies. Experience and know-how of operation of labs, studios and editing rooms helpful. Must be free to travel and have engineering background to sell expanding line of Presto splicers to the trade and government agencies. Unique opportunity for a production man; compensation limited only by ability. Drawing account. Send resume or phone: Leonard A. Herzig, Prestoseal Mfg. Corp., 37-27 33rd St., Long Island City 1, N.Y. STilwell 4-6832.

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Meeting Calendar

National Audio-Visual Convention, July 20–25, Hotel Sherman, Chicago.
National Telemetering Conference, Aug. 20–21, Biltmore Hotel, Los Angeles
Western Electronic Show and Convention, Aug. 21–24, Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles.
Biological Photographic Association, Aug. 27–31, Powers Hotel, Rochester, N. Y.
High-Speed Photography, Third International Congress, including exhibit of high-speed photographic and cinematographic equipment and instrument aids; sponsored by Britain's Dept. of Scientific and Industrial Research, Sept. 10–15, London.
American Society of Mechanical Engineers, Sept. 10–12, Denver.
Theater Owners of America, Inc., Annual Convention, Sept. 19–25, Coliseum, New York.
Canadian IRE Convention and Exposition, Oct. 1–3, Automotive Bldg., Exhibition Park, Toronto, Ont., Canada.
National Association of Educational Broadcasters, Oct. 16–18, Atlanta.
National Electronics Conference, Inc., 12th Annual Conference, Oct. 1–3, Hotel Sherman, Chicago.
Audio Fair, Oct. 4–7, Hotel New Yorker, New York.
80th Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 8–12, Ambassador Hotel, Los Angeles.
Ninth Annual Conference on Electrical Techniques in Medicine and Biology, Nov. 7–9, Governor Clinton Hotel, New York.
Radio Engineering Show and IRE National Convention, Mar. 18–21, 1957, New York Coliseum, New York
81st Semiannual Convention of the SMPTE, including Equipment Exhibit, Apr. 29-May 3, 1957, Shoreham Hotel, Washington, D. C.
82nd Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 4-9, 1957, Philadelphia-Sheraton, Philadelphia.
83rd Semiannual Convention of the SMPTE, including Equipment Exhibit, April 21–26, 1958, Ambassador Hotel, Los Angeles.
84th Semiannual Convention of the SMPTE, Oct. 20–24, 1958, Sheraton-Cadillac, Detroit.
85th Semiannual Convention of the SMPTE, including International Equipment Exhibit, May 4-8, 1959, Fontainebleau, Miami Beach.
86th Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 6-10, 1959, Hotel Statler, New York.

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